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UNIVERSITY OF ALBERTA

STS IN THE CLASSROOM: AN INTERPRETIVE STUDY

BY
KEITH ROSCOE



A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY.

DEPARTMENT OF SECONDARY EDUCATION

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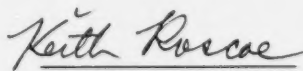
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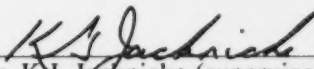
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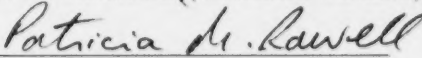
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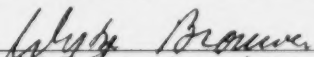
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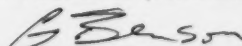
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Abstract

STS IN THE CLASSROOM: AN INTERPRETIVE STUDY

by Keith Roscoe

The science-technology-society (STS) curriculum movement has recently been the focus of a major rethinking of the goals of science education throughout the world, including the province of Alberta, which introduced a STS program to its junior high students and teachers in 1990. In this dissertation, an attempt was made to answer the question "how do teachers experience a new STS curriculum in their everyday working lives?"

An interpretive study rooted in phenomenology and hermeneutics constitutes a systematic attempt to describe and interpret the meaning of lived experience in particular situations. In keeping with hermeneutic theory, an interpretive study also involves the posing of critical questions and the examination of taken-for-granted assumptions and beliefs. Drawing on this theoretical framework, the study centers on the lived experience of two junior high science teachers over the course of their first year of teaching a constructivist-oriented STS course. The empirical component of the study consisted of a classroom investigation involving two grade 7 science teachers over an eight-month period of a single school year. Data collection, including classroom observation, conversational interviews, and document analysis, centered on the teaching and learning of technology and science-and-society units. Also included in the dissertation is a critical analysis of the curriculum, based on Alberta Education publications, documents representing the views of educational stakeholder groups, and relevant literature.

The analysis of the Alberta Program reveals that the curriculum is a compromise which satisfies different demands on the science curriculum, representing various perspectives on the purposes of schooling (academic, utilitarian, pedagogic) and

various assumptions and beliefs about the nature of knowledge and learning. The findings of the classroom study, organized around four existential themes, show that both teachers found more satisfaction in a science program that seemed to provide more freedom of choice, and promote a more social, authentic kind of teaching and learning, as well as more interest and enthusiasm among students and teachers alike. The relative success of the curriculum is mainly attributed to its constructivist orientation to learning which apparently played a role in returning teaching and learning to a more human and less technical context.

Acknowledgements

This study would not have been possible without the full-hearted participation of two very busy teachers, Susan and Richard, who graciously volunteered to share their time, experiences, and teaching insights and wisdom with the researcher. The helpful cooperation of principals of the schools involved and the senior administration of the school district was instrumental in gaining access to schools and teachers, and to the smooth progress of the classroom study. Grande Prairie Regional College made the study possible by providing funds for a sabbatical year and summer sessions, as well as facilitating a flexible teaching schedule, allowing the use of a college vehicle, and much other support.

My dissertation committee—Professors Ken Jacknicke, Wallie Samiroden, and Pat Rowell—were unfailingly helpful, supportive and efficient over the four years of the doctoral program. Particular thanks are extended to my thesis advisor, Dr. Ken Jacknicke, for his always relevant and useful advise and direction.

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CHAPTER 1

Introduction

The pages that follow embody an effort to provide an interpretation and analysis of the experiences of two junior high teachers as they encounter a new science-technology-society course in their everyday classroom lives. The discussion includes an elucidation of positivist and post-positivist philosophical assumptions, their implications for curriculum development, science-technology-society curriculum, and methodology, and a critical appraisal of the science-technology-course involved in the study. It is technical rationality and its pervasive effects, the lived tensions between post-positivist and positivist philosophies, and the notion of pedagogy that constitute the major themes pursued in this study. We discover that for the teachers in the study, a change in the science curriculum brought changes to their classrooms. But what is the context of this curriculum change?

The Social and Educational Contexts

Our times, the late twentieth century, are the scene of unprecedented and often troubling changes for both human social life and nature. In earlier times, for tens of thousands of years humans lived a simple relatively unchanging life, more or less in harmony with nature. But, over the last few millenia came agriculture, then, only a few centuries ago, science and industry, and with them, new ways of viewing the world, with heavy implications for the social and natural worlds. Lately, change has accelerated to unprecedented levels, and our society has become increasingly dominated by science and technology. The home, the workplace, and the school are pervaded by the products of technology, and while we reap their many benefits, we also suffer their accompanying personal, social, and physical side-effects. Family structures, social life, and the demographics of western societies are changing, and often in a disturbing

fashion. Political systems break up and evolve before we can comprehend that we are daily living in a new world. Meanwhile, the human population is growing exponentially, accompanied by the problems and dilemmas of pollution, energy and food crises, environmental degradation, loss of biodiversity, climate change, and so on.

Yet despite earlier attempts at curriculum reform by science educators and scientists, science education has often lagged behind these changes, has seemed unresponsive to what was happening just outside the school windows. Science education in the 1980's in Alberta and elsewhere in North America, was probably not far different from its counterpart decades, or even a century ago (Cuban, 1984; Hoetker & Ahlbrand, 1969; Goodlad, 1984; Tomkins, 1986). Those who perceived this situation as problematic have made efforts to rethink the goals of science education—to bring school science more in line with the social and scientific realities of the modern world (Bybee, 1987; Hofstein and Yager, 1982; Hurd, 1985; Ziman, 1980). Reconceived school science, the STS or *Science-Technology-Society* movement, calls for a return to personal and social goals for science education, an emphasis on informed decision-making, and the knowledge necessary for the future citizens who are left to deal with the legacy of present change. Spurred by this context of change, the STS movement is gaining currency worldwide: by 1988, 33 out of 34 countries surveyed internationally had seen some movement towards STS education (Fensham, 1988).

Meanwhile, in Canada, the Science Council of Canada (1984) recommended a realignment of science education to stress the interactions of science, technology and society in a Canadian context, and to make science accessible to all students. About the same time, in the policy statement Secondary Education in Alberta (1985), Alberta Education mandated changes in secondary curricula "toward preparing students to live

in a changing and complex technological society." Based on this policy, and the Science Council and other reports, Alberta Education began developing a new junior high science curriculum emphasizing the interactions of science, technology, and society. This program underwent mandatory implementation at the grade seven level in 1990.

"Implementation" is often treated as unproblematic by educational authorities and curriculum planners. It is assumed that once the planners have completed their task, teachers will faithfully carry the developers' plans into action. Yet this is an unrealistic expectation, for as Fullan (1982) writes, "the short history of implementation research...shows that planned changes rarely succeed as intended." This is equally true for attempts to implement science curriculum innovations over the last few decades (Welch, 1979). But can we afford to not realize the goals of STS education? Can we afford the failure of planned changes that could provide knowledge needed for succeeding generations to play their role as informed citizens in an ever-changing and threatened world? It is important that we reach a deeper understanding of the nature of STS curriculum, of the interactions of teachers, students, and STS subject matter, and particularly, the ways in which the science teacher, a key curriculum figure, experiences those interactions. The literature reveals that teachers' practice, as indicated earlier, is remarkably stable and resistant to change. To date, little research in science education has focused on trying to understand this stability but, treating the teacher as a "black box," has concentrated on finding ways to coerce teachers to implement centrally planned changes. What is needed is a reframing of the way we view teachers, classrooms and curriculum change, that moves beyond attempts to find more efficient ways of carrying out misguided implementation strategies, towards looking at the

human and unique interactions between teachers and students in the context of STS curricula, and the educational and moral implications of those interactions.

A Personal Context: Autobiographical Reflections

What path has lead me to an interpretive study of the "implementation" of a junior high school science program in Alberta? To begin with, as a child, I was continually and thoroughly enraptured by the natural world around me. Naturally sciences, and specifically biology, enthralled me in school, and were the focus of my interests and career plans through university and graduate studies . Throughout my education, however, I was puzzled by a number of things, for instance, how can something as vitally interesting to young people as the study of the natural world around them be made so lifeless, pedantic, and dull? Like many others, I was bored in school (especially in secondary school), and often asked myself and the occasional teacher, "why are we taking this?", but never getting what I considered to be a satisfactory answer.

After stints as a field and laboratory biologist, interspersed with teaching, it became clear that teaching was where my talent and inclination lay. As an enthusiastic and reasonably successful elementary, junior /senior high and later, college science teacher, I was able to follow my interests in the phenomena of nature, while having the pleasure of sharing this enjoyment with young people, and participating in their growth and development. But I was still troubled by the question "why are we taking this?", as I struggled to resolve the dilemma of addressing externally prescribed curricula, yet creating appropriate and worthwhile learning experiences for my pupils. Later, as a parent I was shocked and disappointed at what seemed to be happening to my own children as they spent time in school, Before attending school (and still at home) they

were so captured by learning and by the world, yet paradoxically were often not finding school educative.

It is this type of concern, an inquietude about teaching, subject matter, and schooling generally, rooted in my own experiences as pupil and teacher in schools in Canada and Britain, that led me to pursue graduate studies in curriculum, the result of which you are now reading. As science-society-technology education came to my attention, and I began to understand its nature and rationale, STS seemed "right"—from the standpoint of the student, the teacher, its goals, and how it spoke to our current situation. When it arose that the Alberta ministry of education would be introducing an STS course into junior high schools at the time I was initiating my doctoral research, a study of the "implementation" of the new course seemed appropriate, timely, and interesting. But reading, reflection and writing in curriculum studies had clarified much of my previously tacit uneasiness about schooling and science education, had drawn me to an abandonment of lingering positivist delusions, and made it apparent that a reductionist search for "factors affecting," or a large scale survey would do little to answer the kinds of questions that were raised by thousands of hours in the classroom as teacher and student.

Those many hours of experiencing classrooms consisted for me, and probably for you as well, not of objective "factors," but of human interaction among students, and between students and teachers. It was teaching and learning infused with emotion and feeling, with right and wrong, so that when you were asked "how was your day," it was the way you *experienced* it that framed your answer, not the degree of efficiency with which you covered the material. And it was the quality, not the quantity, of that experience, that years later, likely determined whether you were still in a classroom or not, and whether you retained anything worthwhile and meaningful from that

experience. It was this realization that pointed towards an interpretive study, a study with a phenomenological focus on the everyday classroom life of a small number of teachers as they and their students met with a new kind of school science, a study that asked *"what would it be like to be a teacher in that situation?"* It was not without trepidation that I embarked on such an investigation, since although I had some experience in scientific research, my background in qualitative methodology was relatively modest, and as far as experience, I had engaged in only two small-scale interpretive studies, one involving elementary children's experience of teachers, the other concentrating on student science teachers' experience of the practicum. Whether I muddled through reasonably well or not, you, the reader, will judge.

What animates me then, as parent, educator, and curriculum researcher, is exploring possibilities for schools to become more educative, vital and humane places for young people and teachers to live and learn. Particularly, I am concerned about the way science has traditionally been taught, but look forward with hope, if not optimism, to the possibilities for change introduced by the STS movement. We are in a time of profoundly disturbing science-related environmental and social problems, of an erosion in public conscience and compassion and in public confidence about the realization of a just democratic society. Yet it is also a time of growing environmental awareness and concern, and of increasing skepticism about technology and the way of thinking that accompanies it. What part can science education play in addressing these developing crises? And most importantly, what kind of future world—social and natural—will our children and their children inherit?

Nature and Intent of the Study.

The intent of the study as curriculum inquiry is threefold: firstly, to try to come to a better understanding of the lifeworld of science teachers as they experience an STS

curriculum innovation, secondly, to inquire into alternative ways of conceptualizing STS curriculum implementation, and thirdly, to mount a critical analysis of STS curriculum in terms of its political and social contexts. The approach in this study necessarily implies a redefinition of the technical notion of "implementation" towards conceptualizing the interactions of subject matter, students, and teachers in a more realistic, humane, and ethically-oriented light. Moreover, a thorough investigation of subject matter—student—teacher interactions as interpreted by the teacher and the researcher must acknowledge not only the agency and subjectivism of individuals, but also the inevitable linkages of subject matter and individuals to political and social influences and values.

The question being posed by the study is framed as follows: *"how do teachers experience a new STS curriculum in their everyday working lives"*? As discussed earlier, this is a phenomenological question that is asking, "what would it be like to be a teacher in that situation?" It is phenomenological in its origins (reflection on the researcher's own lived experience of science classrooms), its substance (lived experience), and its method (reflection on lived experience). Such a question "does not simply iterate what is already given and understood in lived experience...it seeks a transcending theoretical understanding that goes beyond lived experience to situate it, to judge it, to comprehend it, endowing lived experience with new meaning." (Burch, 1989, p. 192). In other words, the intention is to seek an account of teachers' lived experience of curriculum change that encompasses both concrete description and critical reflection.

What I mean by "an account of teacher's lived experience" is not in the form of scientific hypotheses or generalizations that aspire to universality, but of a narrative about the particulars of human social interaction (Connelly and Clandinin, 1986). The

task of interpretive social inquiry is storytelling, interpreting human social life through the use of themes, images, and metaphors (Postman, 1988) so that the reader can reach a deeper understanding of life in some aspect. But of course, storytelling is not just storytelling, anymore than research is just research; there is a moral to the story. And when our story is about teachers and young people, that moral is inescapably *pedagogic*—focused on the nature of our being and acting with children, on what is "right action" in our lives with children (van Manen, 1990).

The empirical phase of the study consisted of an interpretive classroom investigation involving two junior high school science teachers over an eight-month period. Data gathering consisted of conversational interviews, classroom observation, and document analysis, and concentrated on the teaching and learning of technology and science-and-society units in a new grade seven STS program. Data was analysed using a process of thematic analysis (van Manen, 1990), somewhat akin to Glaser and Strauss's (1967) grounded theory approach, but guided more by hermeneutic notions of interpretation. The study contains a review of literature pertinent to the question in chapter 2, a critical analysis of the Alberta Junior High School Science Program syllabus in chapter 3, an account of the methodology used in chapter 4, findings and their interpretation in chapter 5, and concludes with a summary and discussion of the study, and implications of the findings in chapter 6.

Theoretical Orientation

The twentieth century is the first to be determined anew in a decisive fashion by technology, with the onset of the transfer of technical expertise from the mastery of the forces of nature to social life. (Gadamer, 1981, p. 72)

An appreciation of Gadamer's assertion and its implications is crucial to the thrust of this study. Although science itself and the philosophy of science have largely moved on, our society in all its manifestations is still in the grip of an outmoded and

discredited way of viewing the world and society: technical rationality, and its philosophical counterpart, positivism. We live, as Macdonald has it, in a "culture of positivism" (1988, p.104). Positivism is the philosophical doctrine marked by a strong orientation towards science and its methods, which originated in the efforts of nineteenth century philosophers, such as Comte, Mills, and Mach, to emulate the remarkable successes of the physical sciences in other realms of knowledge (Lacey, 1976; Lincoln & Guba, 1985; Polkinghorne, 1983). The positivist movement sought to discover the general principles of science with a view to applying these to the study of human affairs, and ultimately to guide human behavior and social life. Its basic platform is as follows: (a) only scientific methods can produce certain and precise knowledge, (b) facts, constituted by the experience of sense sensations, are the only possible objects of knowledge, (c) anything not reducible to scientific method, facts, and laws, such as metaphysics or theology, is to be rejected (Edwards, 1975; Lacey, 1976; Marcuse, 1968). Modeled on nineteenth century physical science, positivism's key metaphor is the world as a *machine*, while its key assumptions include a single fixed reality that is "out there," objective, value-free knowledge in the form of universal laws made possible by the separation and independence of the observer and what is observed, the independence of facts from time or context, and the linear causality of events (Lincoln & Guba, 1985).

Technical rationality is a term used to describe manifestations of the philosophy of positivism, and its machine metaphor, in human conduct and social organization (Marcuse, 1968; Schön, 1983). What is most significant about technical rationality, like its progenitor positivism, is its *instrumentalism*, or perception of the world in terms of the best means for bringing about predetermined ends (Barrett, 1979; Ellul, 1964). For technical rationality, those ends involve the utilization of the natural and social

world for human purposes—the appropriation of the world in the most efficient fashion possible, using standardized methods (Ellul, 1964; Heidegger, 1977; Marcuse, 1968). Several writers have drawn attention to the way in which modern industrial society is almost completely captured by technical rationality, not only in the obvious shape of technology—technical rationality embodied in a machine—but also in our systems of economic production, commerce, industry, defense, medicine, mass media, and schooling (Barrett, 1979; Ellul, 1964; Marcuse, 1968; Schön, 1983). The significance of this is that "civilization (is) committed to the quest for continually improved means to carelessly examined ends" (Ellul, 1964, p.vi), resulting in an erosion of moral values, dehumanization, and the domination and control of society by the productive apparatus (Barrett, 1979; Ellul, 1964; Marcuse, 1968), not to mention its disastrous effects on the environment. That technical rationality and its insidious effects are immanent in education in North America, including Alberta, will be made clear later.

Despite efforts by neo-positivists like Ayer, Carnap, Hempel, and Wittgenstein to resuscitate positivism in the early twentieth century, positivism as a philosophical movement is now largely outmoded, although its social and intellectual legacy is still widespread and strong (Edwards, 1978). What has emerged from developments in twentieth century physical science, advances in the philosophy of science, and other sources is a group of premises and assumptions, which for lack of a better term, I will characterize as *post-positivism* in this study (Lather, 1992; Lincoln & Guba, 1985; Polkinghorne, 1983). Some post-positivist assumptions are essentially the diametric opposites of their positivist equivalents. For example: there are multiple realities, each uniquely constructed by the observer; knowledge—including facts, theories, methods, choice of problems—is value-laden; the observer and the observed are inseparable, as they interact to influence one another; facts and generalizations are bounded by time and

context; and events shape each other mutually and simultaneously, rather than in simple cause-effect relationships (Guba and Lincoln, 1983). The post-positivist account of science also stresses that facts are theory-laden, and therefore data and theories are inseparable, that theories are just the way the facts are perceived, not generalizations to be compared to nature by hypothesis and deduction, that the laws of science are constituted by our theories rather than by nature, and that theories are to be judged by their coherence, rather than their correspondence with facts (Hesse, 1980).

More recently, other writers have contributed to a radical change in the way we view the world, with implications for education and social research. Prigogine's Nobel Prize-winning research on the thermodynamics of nonequilibrium systems, for example suggests that some parts of the universe, called closed systems, may act like machines, with linear relationships, reversible time, and uniformity (Prigogine & Stengers, 1984). But, Prigogine's work shows that most of the universe consists of open systems, which constantly exchange matter and/or energy with their environment, and as a result are characterized by nonlinearity, irreversible time, change, randomness, and pluralism. Instead of a uniform machine-like universe, with deterministic reversible processes, Prigogine's work reveals a more random, pluralistic, complex, and temporally-bound nature. What this means is a breaking down of the notion of two worlds: the subjective world of particularities and qualities, the familiar world we live in, and the objective scientific world of timeless, context-free universals.

In addition to the insights provided by Prigogine's thermodynamics, chaos theory, the interdisciplinary science of complex systems, has thrown new light on a complex and pluralistic world (Gleick, 1987). During the 1970's, mathematicians, physical scientists, and biologists began investigating irregularities in complex systems, discovering that there are regularities and patterns at many levels within disorder, and

Another significant finding of both modern physical science and systems theory is that the fundamental reality of systems lies not in the substance of their components, but in their *processes*. At the level of the atom, quantum theory tells us that particles such as electrons are to be considered vibrations or energy relationships, while at a higher level, an ecosystem is defined by the interactions between organisms and their environment. Systems theory suggests that in order to understand any complex system, we should "think interaction" (Davidson, 1983).

Von Bertalanffy, the "father" of modern systems theory (Davidson, 1983), proposes that based on this view of the universe, the most appropriate metaphor to replace the machine would be the *organismic conception* (1975). The concept of the *organism*, or when appropriate, an alternative level of biological organization such as the *ecosystem*, or the *cell*, encapsulates the ideas of interdependence, connectedness, plurality, nonlinearity, interaction and so on that typify the complex open systems of most concern to human beings. From the standpoint of educational and other social research, what is powerful about the organism metaphor, besides its elegance and explanatory capacity, is that it restores something missing from the basic premises of the machine metaphor. When humans as well as the rest of the universe are conceived as machines, those fundamental features that set humans off from the rest of the living and non-living world are lost: creativity, freedom of choice, responsibility, and moral values. A systems perspective, von Bertalanffy argues, recognizes the human being as the ultimate expression of organized complexity, with emergent qualities such as traditions, values, and morality (Davidson, 1983). Furthermore, he sees the control of man and nature by technology and the resulting disruption of human value systems as a direct threat to both individuals and society, such that "only a rehabilitation of ethical

that ordered structures can arise from disorder and the rhythms of nature (Capra, 1982). This further supports the view of a world that is at once deterministic and nondeterministic, orderly and disorderly, machine-like and organism-like, depending on where one focuses attention (Gleick, 1987). Chaos theory requires a holistic approach that is breaking down barriers between the science disciplines, and seems to be reversing science's proclivity for reductionism and deterministic predictability (Gleick, 1987). In other words, *nature is looking less and less like a machine*, and closer to a more intuitive and less alienating view of the world.

What form a new metaphor for nature might take is suggested by "systems theory," an interdisciplinary body of thought developed over the last several decades which draws upon biology, cybernetics, engineering, mathematics, psychiatry, and philosophy, as well as embracing the newer findings of chaos theory and thermodynamics (Capra, 1982; von Bertalanffy, 1975). Systems theory conceives the world in terms of the interconnectedness and interdependence of phenomena, whether biological, physical, psychological, social, or cultural. A *system*, any complex of interacting components, acts as an integrated whole, whose properties cannot be reduced to those of its component parts (von Bertalanffy, 1975). Complex systems, whether organisms, inanimate matter, the global climatic system, or societies, tend to have a hierarchical or stratified organization with many levels, such that each level is part of the whole, but also forms a whole itself with emergent qualities not found in its parts (Capra, 1982; Mayr, 1988). This is why systems theory takes a *holistic* approach, based on understanding reality as an integrated whole, rather than using a reductionist approach which splits problems into their smallest components to investigate phenomena.

and religious values can prevent the decline of the West" (von Bertalanffy, 1975, p. 52).

What does all this mean for society, for social research, for curriculum, and for this study? Firstly, it means that at the intellectual level, the informed researcher is obliged to attend to these post-positivist ideas, to abandon outmoded positivist assumptions, to reformulate the way he or she views the world, and to conduct research accordingly. Scientistic social research, and scientistic tendencies within qualitative research, represent a naive nostalgia for *certainly*—for the long since-vanished Newtonian sciences, with uniformity, precision, order, determinism, and predictability in a machine-like universe. Social research must move on, in keeping with present knowledge and realities. It means that alternative modes of research, such as interpretive or critical research, must be carefully founded on the implications of a post-positivist world view. For curriculum, this means that not only curriculum practices, such as development, implementation, and evaluation, should be in keeping with current (as opposed to nineteenth century) insights, but so too should curriculum research. It is my intention in this study to maintain as strong as possible a congruence between post-positivist thought on one hand, and methods used, interpretations and propositions put forward, and conclusions drawn, on the other.

But when we turn our attention from the academic to the social world we are faced with a contradiction. Even though positivism is intellectually passé, its residue lingers in modern industrial society and social practice. Technical rationality is alive and well in practically every sphere of modern life, and what concerns us most here, is that it governs the way society conceives schooling, curriculum and young people, and penetrates to the innermost recesses of the home and classroom. The identification and

clarification of technical rationality as embodied in instrumental views of curriculum, and the suggestion of more humanistic alternatives are major tasks of this work.

Significance of the Study

Relatively few "implementation" studies have been carried out in science education in recent years, and even fewer studies have concentrated on S-T-S programs. Solomon suggests that "there is precious little research on the results of STS education within schools" (1988a, p.278), while the Science Council of Canada calls for research concerning the impact and meaning of new STS approaches for teachers and students (Orpwood & Souque, 1984). Furthermore, very little interpretive classroom research on STS curriculum has been conducted, especially research which conceives teachers and pupils in non-instrumental terms, or seeks to deepen our understanding of the classroom lifeworld of teachers and students. Fullan (1983) writes that the "neglect of the phenomenology of change—that is, how people actually experience change, as distinct from how it might have been intended—is at the heart of the spectacular lack of success of most social reforms" (p. 4). Similarly, Olson (1982) calls for a hermeneutic/phenomenological analysis of science curriculum change, a type of research that aims at understanding teachers' lived experience from their own point of view and strives for an understanding of teachers' intentionality and the contradictions associated with innovations. Finally, the unquestioning "boosterism" and "scientism" of much STS literature needs tempering with studies, such as this, that pose morally-oriented critical questions to science curriculum.

Interpretive research on science curriculum change from a phenomenological-hermeneutic perspective has significant implications for policy. According to Stake and Easley (1978), "that the problem (of curriculum implementation) is less one of willingness than of contradictory purposes has implications for future plans at reform;

the receiving organism must be understood and respected." Curriculum authorities who see their responsibility as promoting improvement in science education at a time of unprecedented change should develop a better understanding of the complexities of classroom life, of the nature of teaching, of what can and should be done in classrooms, and come to realize the nature and human costs of technical rationality in their practice. For practitioners, the study may not only affirm their own practice, but may also lead to critical reflection upon and understanding of the nature and complexity of their daily work. The study may provide metaphors, ideas, issues or inspiration for dialogue with colleagues—about teaching and learning in general, and teaching science-technology-society in particular, about pedagogy, the state of our society and the place of schools in it.

The literature reveals that not enough is known about the nature of classroom life, and that we generally have a poor understanding of the interactions of new subject matter, teachers, and students in specific situations. Especially, we need to know more about the ways in which the teacher, the key curriculum figure, experiences change. Fullan (1982, p.) acknowledges that "a great deal of work remains to be done in conceptualizing the meaning and processes of implementation." Rapid future societal and environmental change is likely to generate continuing pressure from various quarters for educational improvement and innovation, particularly in science and technology education. Will promoters of more humane non-technical views of society and the world be able to mount cogent and telling critiques on instrumental approaches to STS curriculum? Will alternatives to the present technical and bureaucratic notions of curriculum development and implementation be available for reflection and deliberation—alternatives that ultimately may be important for our common future?

CHAPTER 2

Review of the Literature

We now come to a consideration of how previous research has given shape to the question posed in this study. Which relevant theoretical and empirical literature does the study build upon, which are the important issues, and how does this serve to clarify and define the study's central problem, of the meaning of a STS curriculum innovation for teachers' working lives? I make a case for the reconceptualization of curriculum implementation in the direction of Aristotle's notion of "practice," for a reading of teachers' classroom life rooted in complex uncertainties, on one hand, and stability on the other. Finally, I explore major issues in science-technology-society curriculum, and examine significant classroom-based research, and suggest how this study might contribute to our present understanding in these areas.

Research in Curriculum Development

Curriculum Development in a Technological Society

The question of how classroom life should be conceived is a matter of dispute in the literature, depending on what is assumed about the nature and purpose of schools and teaching. There is good reason to believe that our thinking about all aspects of modern life, including schooling, is dominated by technical reason, a rationality and accompanying set of assumptions that seeks standardized means for efficiently attaining predetermined ends (Ellul, 1964). The industrial revolution, the resulting transformation of society in the nineteenth century, and our present hi-tech society have been made possible by a blossoming of technical reason in industry, and its subsequent penetration into the fabric of the social milieu. But what are the consequences for education?

It is argued that in the early part of the twentieth century, North American education underwent a technical metamorphosis, as scientific management techniques were borrowed from industry by educational administrators and curriculum theorists (House, 1979; Kliebard, 1975). These techniques stressed productivity, standardization, and above all efficiency, applied towards the achievement of predetermined social ends. In the late twentieth century, the central metaphor for curriculum theory and educational administration is still *production* (Kliebard, 1975), the school-as-factory, with the child perceived as raw material, desirable behaviors as products, the teacher as a technician, and teaching as a technical activity. Schooling has increasingly come under bureaucratic control, curriculum planning is more centralized in many areas, and "top-down" strategies of curriculum development have become firmly established. For those curriculum authors who accept technical reason applied to schools, and the production concept of schooling, these developments are logical and unproblematic.

Fullan (1982, 1991a, 1991b) is a major Canadian curriculum researcher who has characterized curriculum development along these lines. He describes widely used technical curriculum development strategies which typically involve several stages: (1) initiation, (2) implementation, (3) continuation, and (4) outcomes (Fullan, 1982). In Alberta, for instance, where such strategies are in use, *initiation* might involve such processes as research, needs assessments, proposals, a decision to adopt, program development, and validation (Alberta Education, 1989). These development activities are carried out by education departments, often with participation by committees representing various interest groups (teachers, administrators, business, industry, other community members). *Implementation* is identified as the "process of putting a change into practice" (Fullan, 1985). Development strategies employed to introduce and

implement programs in the top-down model include inservice training, resource support, and feedback mechanisms (Fullan & Pomfret, 1977). *Continuation* involves maintaining and monitoring the program over a period of several years as the program becomes established, and making any necessary revisions (Alberta Education, 1989; Fullan, 1982). Finally, *outcomes* refers to the process of assessing student learning outcomes along with the overall efficiency and effectiveness of the program in relation to given criteria (Alberta Education, 1989; Fullan, 1982).

Technical reason is seen to be at work in these top-down curriculum development strategies. Predetermined ends are fixed at the "top" through central planning by bureaucrats, possibly with input from curriculum committees representing different stakeholders. Through a linear process, the plans are disseminated "down" to the classroom to be implemented by the teacher-technician. Quality control is enhanced by "implementation strategies" and by evaluation. The product—student learning outcomes—is evaluated in relation to the ends determined previously at the top.

In this model of curriculum implementation there is a clear division of labor. The curriculum developers are to produce a plan—guided by government policy, perceived societal needs, learning expectations for students, subject matter knowledge, and a general knowledge of the learning environment. The classroom teacher's task is to put the plan into action. The teacher may amount to a "mere transmitter of ideas" (Connelly, 1972), a passive technician using teaching skills to find the best means to carry out ends determined elsewhere, not acting freely but mandated by law to implement the curriculum. The top-down approach implies that teachers need to be told what to teach, how to teach it, and how to evaluate what they have taught.

Of course, there may be positive aspects of centralized curriculum planning. It could be argued that it provides a minimum standard of education and some curriculum

uniformity for students throughout a jurisdiction, and that it aids in teacher preparation and deliberation about subject matter. It may be the case that some teachers are happy to assume the role of passive technician. Despite this, there is evidence that the net effect of "top-down" development policies in schools and classrooms, of the intrusion of bureaucracy into students' and teachers' lives, is not positive (e.g. Barrow, 1984; Samiroden, 1990; Wideen, 1990).

Technological Implementation Research

Research, as well as practice in curriculum development, has been dominated by technical thinking. Educational researchers have tried to emulate the success of the physical sciences in searching for lawlike generalizations about isolated factors involving the teacher, the learner, the curriculum, or the school, with the aim of predicting and controlling classroom events. Technological research on implementation thus accepts the bureaucratic top-down approach as given. Implementation studies, according to Fullan (1991) have two main perspectives: *fidelity* or *mutual adaptation*. The fidelity perspective, which includes the vast majority of implementation studies, assumes that the goal of implementation research is to determine the degree to which actual use in the classroom corresponds to planned use. Particular characteristics—specific teacher and student behaviors, curriculum materials, teacher self-rating scales—are assessed to see how faithful practice is to planning, i.e. how well the curriculum has been "installed" in the school-factory. The adaptation perspective makes more concessions towards the realities of classrooms, in assuming that all teachers will adapt curricula to suit their own situations. Research of this type looks for different degrees of variation in practice from the plan (Fullan & Pomfret, 1977), but prespecified ends are paramount and the assumptions inherent in technological strategies of curriculum development are still unchallenged.

But how valid is the technical model of curriculum development, and how fruitful has it been over the last few decades? It may be true that we know more about curriculum issues, and perhaps curriculum materials are more sophisticated than in the past (Connelly, 1972). Nevertheless, as Fullan (1982) suggests, "the short history of implementation research...shows that planned changes rarely succeed as intended" (p. 6). There are numerous research studies demonstrating that the vast majority of curriculum development initiatives of the 1960's and 1970's in North America and Britain did not get "implemented" in classrooms as planned (e.g., Berman & McLaughlin, 1977; Fullan & Pomfret, 1977; Giacuinta, 1973; McDonald & Walker, 1976; Welch, 1979). Initially, in the 1960's, the emphasis was on large curriculum development projects, such as the various nationally-funded "alphabet" science curricula in the U.S. (Welch, 1979), and the Nuffield projects in Britain (McDonald & Walker, 1976).

It was soon realized that the teacher was not a passive "black box" in the curriculum development process, and that the relationship between program aims and student outcomes could not be examined without understanding the implementation process (Berman & McLaughlin, 1977). Attention then turned to discovering factors facilitating or inhibiting implementation and better strategies for implementation (Connelly & Elbaz, 1980). The teacher was identified as a key figure in the implementation process but was often dichotomized in the literature as either "a rational adopter" or "a stone-age obstructionist" (Doyle & Ponder, 1977). Rather than trying to understand the reasons for classroom stability in the face of imposed curriculum change, technological curriculum research continues the search for more effective ways to "influence" teachers (Fullan, 1991), for ways to make the technological approach work, in the face of rapidly accumulating evidence that it is a degenerative research

programme (Lakatos, 1970).

Reconceptualizing Curriculum Development

Teaching as Practical Action

Why then, is technological curriculum development not a valid conception, and why has it failed? The Aristotelian tradition of philosophy provides a still vital illumination of this question. In Nicomachean Ethics (1962), Aristotle distinguishes between two kinds of human action: production and practice. Production (*poiesis*), or "technical action," is the economic basis for the life of the state. The artisan's technical skill or "know-how" (*techne*) is employed in the making of a product according to a plan or purpose set by an outside authority. Here Aristotle makes a sharp distinction between ends and means, since the artisan's work is only important insofar as it achieves the desired product—the action has an end other than itself. There is some scope for decision-making in technical action, but choice is restricted to the best means towards preset ends: how to best deploy one's technical expertise.

Against technical action, Aristotle sets practice (*praxis*), or practical action, the human inter-action of political life in society. Practical action is guided by *phronesis*, "practical wisdom," which encompasses practical knowledge and deliberation or judgement (Grundy, 1987). Practical knowledge is the knowledge that gives direction to action, that arises from practice and is related back to practice (Gadamer, 1981). It is personal knowledge in Polanyi's (1962) sense—derived from experience through reflection and reason. Practical judgement implies rational deliberation about what is the "good" for fellow human beings. "Good action is itself an end" (Nicomachean Ethics, 1140b). That is, practical action is to be judged on its own terms, on the degree towards which it furthers the "good," rather than on its achievement of some external purpose. A key concept in Aristotle's notion of practical action is *prohairesis*, the act of

conscious choosing in deliberation (Gadamer, 1981), which implies free choice, or human moral agency. And so Aristotle distinguishes between the *technical*—skilled production of material products with the means predetermined by ends, and the *practical*—free, conscious, deliberative action "with regard to human good," with ends and means morally co-determined.

It seems evident from this that classroom teaching is more akin to practical action than technical action; that technological curriculum development strategies fail because they misconceive the nature of the teaching act. The classroom is not a factory, with skilled technicians producing manufactured articles to exact specifications, but a place for human interaction, with teachers acting with some degree of freedom, and ideally, at least, oriented to the human good of their pupils. What is needed is a more complex, realistic and sensitive perspective on curriculum development which recognizes teaching not as technique, but as "practice."

The concept of the practical was introduced into contemporary curriculum discourse by Schwab (1969). He suggests that the proper business of the curriculum field is *the practical*—deliberation and decision-making in concrete educational situations, rather than the theoretic—the search for broad warranted principles with general application. In an influential later paper, Schwab (1973) identifies four features or *commonplaces*, that all educational situations have in common. These are: teachers, students, subject-matter, and milieu. According to Schwab, any educational situation is best understood in terms of the interactions between teacher, students, subject matter, and milieu (or context). Consequently, the practical action of teaching involves practical deliberation and decision-making about interactions between teachers, students, and subject matter in a specific classroom, school and community context. Teacher curriculum deliberation, in Schwab's view, would involve independent

decisions about the most appropriate interaction of particular students with given subject matter in that educational situation.

The Teacher as Autonomous Curriculum Agent

Connelly (1972) was among the first curriculum writers to reformulate curriculum development along the lines proposed by Schwab. For Connelly, implementation studies document the fact that "teachers are *highly autonomous agents* with respect to externally developed materials," and furthermore, "this autonomy (cannot) be circumvented by augmented top-down development strategies" (p. 164). He also focuses attention on the practical nature of teachers' work, in depicting the teacher's role in curriculum development as practical deliberation about the "right action" for particular students and circumstances. The ideal relationship between central curriculum developers and classroom teachers in Connelly's model would be a symbiotic partnership, rather than a top-down chain of command.

Each partner in this model—the "external developer" and the "user-developer" (teacher)—would have a particular body of knowledge, orientation, and function. Each partner would be complementary to the other; both necessary for the overall success of curriculum development. An external developers' function would be to develop a product—a curriculum guide and other curriculum materials—to provide curriculum alternatives for teacher choice, according to their circumstances and professional judgement (Connelly, 1972). The method of external curriculum development is by nature predominantly technical action—the construction of a product according to prespecified ends. Decisions are guided by government policy and the general goals of education, by the results of contestation between different interest groups, by general knowledge of the nature and needs of learners and the nature of learning environments (Alberta Education, 1989). However, the developers' main orientation is likely

towards subject matter. The curriculum products produced will of necessity be general, for hypothetical students, but must nonetheless provide sufficient specific alternatives for teacher deliberation and choice (Connelly, 1972). In general, the overall function of external curriculum development in this model would be to provide direction and ideas for teachers.

On the other hand, the teacher, or "user-developer," in Connelly's framework would be oriented to the particular and the practical, to the classroom. In carrying out their function of practical deliberation about what to teach, how to teach it, and how to evaluate it, teachers would strive to make decisions guided by the needs of particular students, and by their own preferences, beliefs and commitments. This model supports the notion that the end of teaching is practical *action*, not a material product. Teachers' knowledge is probably not the general expert knowledge of curriculum specialists, but practical knowledge of their students and situation derived from their experience, while their orientation is ideally more towards students and human relationships, than to subject matter. The teacher is conceptualized by Connelly as an autonomous curriculum agent, who makes defensible choices about what is right for their students under particular classroom circumstances, rather than the passive functionary portrayed by the technological research tradition, who undoubtedly has some representatives among the ranks of teachers.

In her work, Elbaz (1981,1984) seeks to support this conceptualization of the teacher's role by demonstrating that teachers can hold and use "practical knowledge." She suggests that a teacher's practical knowledge arises from practice, but at the same time is used by the teacher to shape ever-changing teaching situations. The practical knowledge of the teacher in Elbaz's case study was diverse in *content* (subject matter, curriculum development and organization, instructional techniques, school milieu, self)

and in *orientation* (situational, personal, social, experiential, and theoretical). The teacher used her knowledge in complex ways which embodied her intentionality, her experience, her personal beliefs, feelings, values, and needs. "Practical principles" guided the teacher's use of knowledge in reflective and deliberative situations, while "images," or metaphors brought the teacher's knowledge to bear in a more intuitive way. Elbaz's research provides support to the argument that teaching is a practical activity, by demonstrating that teachers possess a body of practical knowledge which originates from practice and in turn shapes practice, in a dynamic interaction of experience, reflection, deliberation, and intuition. Teachers' practical knowledge as unique, situational and personal, legitimates the notion of teachers as an autonomous curriculum agents in the classroom.

Reid (1975) contends that the existence of such a common pool of accumulated skills and beliefs is what makes schooling possible. The practical knowledge of teachers in schools and the more specialized and general knowledge of the curriculum planner are not interchangeable: the situational knowledge of teachers is the soil in which the seeds of curriculum change must be sown. External curriculum development, Reid suggests, should be "a resource to help schools develop courses appropriate to them and their students," and to deflect them "from the path to which overriding constraints commit them" (1975, p. 251). While Reid's ideas about the function of curriculum planning, and its relation to classroom stability warrant consideration, he neglects the part of the individual teacher in this. The literature suggests that the teacher has a degree of autonomy in the classroom, as well as practical knowledge. Both Reid and Connelly have probably underrated the role of the teacher in *creating* curriculum alternatives, as well as choosing among given alternatives.

Support is also given for the idea of teacher agency by the notion of "curriculum potential" (Ben-Peretz, 1975). The technological conception of implementation requires that teachers convert developers' intentions into practice, and act as passive conduits for the ends of higher authorities. Of course, teachers do not fulfill this role: "teachers are relatively autonomous in their implementation of new programs," so that there are almost as many different versions of a curriculum as there are teachers (Ben-Peretz, 1975). Rather than regarding curriculum materials as strictly embodying developers' intentions, Ben-Peretz suggests that the potential of a curriculum includes not only the developers' intentions but also unintended positive and negative outcomes in classroom use, in addition to unplanned innovative possibilities seen by the teacher. Shipman (1974) illustrates this process at work in a case study of a British curriculum project in which a curriculum innovation acted as a catalyst to teachers. Teachers developed the curriculum along several different lines unanticipated by developers' intentions. For Shipman, "it may be the catalytic ("spin-off") effects of projects that are more important than the limited impact of specific curriculum objectives" (p.125). In other words, the nature and logic of curriculum materials is such that they should be seen more as sources for teachers' deliberation and flexible adaptation to unique classroom situations, than as "rigid frameworks" to be enforced.

The Teacher as Moral Agent

A number of curriculum writers have drawn attention to the practical-moral nature of teaching. Ernest House (1979), for instance, makes a basic distinction between conceptions of "teaching as technology" and "teaching as craft." A technology is based on explicit knowledge and principles learned through formal means, but a craft is based on tacit knowledge and experience learned through apprenticeship. It is evident that teaching is, in these terms, closer to a craft. However, what Ben-Peretz,

Connelly, Elbaz, House, Reid, and others overlook or underemphasize is the *fundamentally normative* nature of the teaching act. Tom (1984), for instance, acknowledges that teaching is a craft, based on knowledge accumulated over years of experience, involving critical reflection, deliberation, and defensible choice, and using methods that sometimes succeed and sometimes fail. But more than this, he portrays teaching as a *moral* craft. Tom asserts that teaching is a moral endeavor in two ways. Firstly, the asymmetrical power distribution between teacher and student means that the teacher-student relationship is "inherently moral." The teacher has control over students, yet at the same time is responsible for their growth in desirable directions. Secondly, the teacher is called to select worthwhile subject matter which will promote growth, and is truly educative.

The interactive nature of teaching, also emphasized by Tom, situates it within the sphere of Aristotle's practical: human *inter-action*. Technical approaches objectify teachers, students, and classrooms, focusing on observable behaviors, predictable outcomes, manipulation and control, tending to dehumanize education. But Goodlad (1984) writes that "the central task of teaching is humanizing knowledge" (p.9). This focuses attention on the idea that teaching is essentially subjective interaction between teacher and students. Aoki (1983), for instance, portrays implementation as "situational praxis," grounded in human experiences in the classroom. His view of implementation sees the teacher not objectified, but as "a human being interested in his own and other's becoming" (p.14), and the school as "a community of very human beings" (p.17). Aoki sees the classroom as a social world in which there is a dialectical relationship between the teacher's subjectivity and students' subjectivity (1978).

Tom, Goodlad, and Aoki remind us that teaching is grounded in human interaction in the classroom, and in the quality of the relationships between teacher and

child. Van Manen (1990) situates the "good" in the practice of teaching more fundamentally in *pedagogy*. His use of the term "pedagogy" is more in line with continental European usage than with the North American sense of teaching, curriculum, or instructional procedures. Pedagogy, van Manen says, "inheres in our phenomenological response to the child's natural helplessness; we recognize there is a natural need to do right with the young child" (1990, p.146). For this reason, pedagogic action is pre-theoretic and pre-reflective, involving an embodied practical knowledge.

Van Manen (1990) considers that the pedagogic relationship between parent and child or teacher and pupil is normative in the sense that competence, reliability and responsibility are fundamental "living norms" in our lives with young people. Beyond this, he suggests that pedagogy orients us to personal growth and learning, to what the young person can know and become, through an openness to the child's subjectivity, and a subtle holding back as well as tactful action. "Pedagogic tact" is the sensitivity to a situation that enables a person to do the right thing for a young person in a given situation, something Aristotle called *phronesis*, or practical wisdom (van Manen, 1984). What allows us to act tactfully is "pedagogical thoughtfulness," the process and product of our reflection on living with children, related to tact through the ontological principle of authentic personal being: in the way we are with children. And so pedagogy serves the *pedagogic good*: "the end of education, the end in itself, from which all our hope, love, and inspiration for children draws its meaning" (van Manen, 1982, p. 47). While this may be a somewhat idealized account of teachers' orientation to students and their well-being, it does alert us to the possibility of a deeper commitment on the part of teachers than simply "doing the right thing" for other people's children.

A number of empirical studies lend weight to the argument that teachers act as moral agents, albeit with divergent notions of what constitutes "the good" for pupils. Secondary teachers in Lortie's sociological study (1977) saw themselves as moral agents responsible for the socialization of students towards good citizenship and compliance with classroom and societal norms. They saw their role as preparing their students for life, "trying to produce good people." Case studies of science teachers in the US and Canada also have described a powerful "*socialization ethic*" (Stake & Easley, 1978; Olson & Russell, 1984). This entails developing students' work habits, attentiveness, preparedness, ability to learn from written materials and follow instructions, compliance to social norms, and so forth. Socialization of students is apparently the dominant goal of North American science teachers, taking precedence over subject matter, regardless of the particular social values of the teacher. Science content and instructional materials seem to be used more as ways of socializing students into school and societal norms, than as means of achieving academic aims (Stake & Easley, 1978).

Another significant moral imperative reported for science teachers is the "*preparation ethic*" (Olson & Russell, 1984; Stake & Easley, 1978). Teachers are said to feel a strong responsibility for the preparation of students for subsequent levels of science education—the content and skills needed for successful passing of examinations, graduation from high school, success in college and later employment. There is a strong sense that both the students' futures, and their teacher's credibility are on the line if students don't "cover the material." These studies of secondary teachers' moral intentions reveal somewhat narrower conceptions of what constitutes "growth in desirable directions" than those of Tom or van Manen, for example. Personal growth and learning was conceived by teachers in terms of educational and economic success

and conformity to school and societal norms, rather than as movement towards intellectual development, autonomy and freedom. As Cuban (1984) has noted, individual teachers' values, beliefs, and experiences will tend to shape their decisions about what is "good" for students, regardless of educational authorities notions of the "good."

The Classroom Experience for Teachers

Demands and Constraints

So far we have considered ways in which curriculum development, and specifically the act of teaching, might be conceived. Now we turn our attention to the question of the meaning of classroom life for teachers. In general, and specifically for science teaching, what does the literature tell us about how teachers experience their everyday working lives in the classrooms? What is the structure of that experience, and what are the issues, what are the dilemmas?

Contradictions and tensions are part of the human condition (van Manen, 1991). This is especially so for our lives as adults living with children—as parents and as teachers. Teachers are confronted in an ongoing way with a stream of dilemmas and contradictions in their classroom lives: the individual versus the group, freedom versus control, personal knowledge versus public knowledge, self versus other, and so on (Berlak & Berlak, 1981). Opposing qualities, assumptions, values, and beliefs within the individual, the classroom society, and the larger society structure the lifeworld of the classroom.

There is surprisingly little empirical research on classroom life, but studies from what House (1979) calls the "cultural perspective" have revealed glimpses of these opposing tendencies in schools. Westbury (1973) argues that we should see the classroom as "an environment that contains demands (and therefore tasks for the

teacher) and constraints that are inherent in its nature, given existing goals, structures and resources" (p. 100). The tensions between the demands and the constraints of the classroom create the contextual reality which teachers must deal with in their everyday working lives. The conditions for teaching constitute what Jackson (1968) calls "living in a crowd": a teacher and twenty or thirty energetic young people of diverse abilities and backgrounds (but who are not necessarily interested in the subject matter) confined to a crowded classroom for varying periods of time. Teachers are constrained by the circumstances under which they teach—too many students in a confined and inflexible space, too many hours of classes each day, administrative controls, and so on (Goodlad, 1984).

For teachers, classroom life inevitably gives rise to many demands. The basic demand is to maintain control in the classroom—in order to survive, to prevent unruly students from taking over, and as a basic condition for teaching and learning. At the junior high level in particular, student misbehavior is perceived by teachers to be a major problem (Goodlad, 1984). But the teacher is faced by many other compelling and continuous demands: subject matter learning, maintaining positive relationships with students, keeping students interested, socialization of students, administrative tasks, and so forth (Lortie, 1975).

Sarason (1982) points out that the complexity of the teacher's task lies not only in the number and diversity of children and tasks they must deal with, but also in the demands of a predetermined curriculum, which gives rise to "the felt necessity to have the class reach a certain level of skill and knowledge in a fixed period of time" (p. 187). In an era of "accountability" and achievement tests, teachers feel subject to this *time pressure*, the perception that their worth as teachers is judged by how much their classes learn in a given time period, and how well students perform on external

examinations. The tension between the complex and varied tasks of the teacher, and the lack of time to perform them brings about many difficult-to-resolve dilemmas, for example: subject matter learning versus student interest and motivation, attending to individuals versus attending to the group, and covering the curriculum versus student understanding (Berlak & Berlak, 1981; Lortie, 1975; Olson & Russell, 1984).

Teachers work under a number of other constraints, besides the major "enemy"—time. For instance, the goals of education are largely intangible, and success is difficult to assess, unlike in other professions (Lortie, 1975). A doctor or a lawyer receives fairly unambiguous feedback about their success (patient recovers or dies, client found guilty or not guilty), but as a teacher it's often hard to tell how you're doing. Thus the rewards of teaching are hard to come by, while the daily demands are not easily met (Lortie, 1977; Sarason, 1982). Teachers report difficulties in gaining access to scarce resources or materials, notably for science classes (Lortie, 1975; Olson & Russell, 1984). Other perceived constraints for teachers include a lack of subject matter knowledge, and the pedagogical skills and strategies to further a variety of educational goals (Olson & Russell, 1984).

Classroom Stability

Thus the task of teaching is described by researchers as demanding, ambiguous, uncertain, and open-ended (Lortie, 1975; Olson, 1982; Olson & Russell, 1984). Even the most enthusiastic and capable teachers apparently find ways to cope with the continuing physical, intellectual, and emotional demands encountered in the classroom by turning to protective routines that minimize these demands (Goodlad, 1984; Sarason, 1982). Teachers cope with the ambiguity and uncertainty arising from the dilemmas of schooling by finding ways to make the job less threatening and ambiguous. Cuban's (1984) historical study involving almost 7,000 different

accounts of classrooms up to 1980 reveals "the persistent occurrence of teacher-centered practices since the turn of the century" (p.238). In an earlier review of classroom observational studies in the U.S. from before the turn of the century to 1950, Hoetker and Ahlbrand (1969) note the remarkable persistence of the textbook-oriented, question-and-answer "recitation" method. They ask, "what is there about the recitation that makes it so successful in the evolutionary struggle with other more highly recommended methods; what survival needs of teachers are uniquely met by the recitation?". By way of explanation, Westbury (1973) argues that the recitation "permits teachers to deal, at least in a minimally satisfactory way, with the tensions that (the) interaction between demands and constraints creates" (p.100). Apparently, North American teachers have dealt with these tensions in characteristic ways for a century or more.

For instance, in their case studies of science education in Canadian schools, Olson and Russell (1984) found that teachers developed a number of ways of coping with uncertainty in their working lives. Secondary school science teachers emphasized exact copying from board notes or activity sheets, following procedures exactly in labwork, getting the "right answers," and "covering the material." This "cut-and-dried" approach is interpreted by Olson and Russell as a way of controlling and channeling students' energies by keeping them busy doing routine, unambiguous and (if possible) interesting work. In addition this system is efficient: easily performed by students and easily checked by the teacher. Finally, maintaining credibility also appears to be a major concern for science teachers (Olson & Russell, 1984; Stake & Easley, 1978). Teachers are reported to use subject matter and teaching skills to demonstrate their competence and to keep students' respect. This issue for teachers may have

implications for the introduction into classrooms of new content, materials, or teaching methods which might threaten credibility.

Cuban (1984) theorizes that the organizational structures of schools and classrooms provide the boundaries within which the culture of teaching and individual teacher agency shape practice. Several researchers describe a cultural tradition in schools in which teachers teach the way they were taught, since other models of teaching briefly encountered during teacher education do little to counteract a decade or more of close, formative contact with teachers of previous generations (Cuban, 1984; Sarason, 1982; Reid, 1975). Furthermore, new teachers are perhaps funnelled into stable patterns of teaching in student teaching and their first years of teaching by mentors and by the sheer necessity to survive, while the prevailing values of the school and the larger society tend to reinforce the tried-and-true techniques.

But in her study of the social organization of elementary schools, Rosenholtz (1989) found that this picture is perhaps oversimplified. There seemed to be two very different kinds of cultures in the schools she studied: high consensus and low consensus. In high consensus schools, shared goals and an optimistic sense of community made possible a climate of collaboration, an ethic of continuous improvement among teachers, and a pedagogical orientation towards pupils. Low consensus schools, on the other hand, featured a climate of isolation and self-reliance, in which teachers had reverted to mere survival and fatalistic coping strategies, and a much lower regard for their students. This research implies that teaching practice is not only bounded by the organizational structure of schooling, but also by the unique social life of each individual school, or perhaps school district, which determines whether teachers engage in "professional or production-line work" (Rosenholtz, 1989, p. 211).

The body of sociological case study research discussed above, while providing valuable insights into teachers' classroom life, fails to get at deeper levels of meaning in teachers' everyday lives. Specifically, there is a need for more empirical curriculum research from a phenomenological perspective that is sensitive to the experiences and meanings of individual teachers, to the intersubjectivity that constitutes the lifeworld of the classroom, to the pedagogical implications of everyday interaction with young people. Also neglected is research of this nature including a stance which questions taken-for-granted aspects of classroom life. One example of such work is Parker's 1986 study of two elementary teachers' experience of a curriculum innovation (computer assisted instruction) in their working lives. Parker re-emphasizes the themes of uncertainty and stability in classroom life, and the teachers' agency and autonomy in dealing with a curriculum invention encountered earlier in this discussion. But he also focuses on the *pedagogic hope* that permeated the teachers' relationships and thoughts of their pupils, "a loving orientation towards their children as beings becoming"(p.25), but at the same time was in tension with the ambiguity and strains of their everyday lives with children. Research along the lines of Parker, and hopefully the present study, will contribute to a deeper, less superficial understanding of curriculum change.

Research on STS Science Curriculum

A Rationale for STS Education

Recently, science education, like curriculum research in general, has undergone hotly contested debates over the nature and scope of its subject matter. The last major science curriculum initiatives were those of the 1960's and early 1970's: the major American curriculum projects which focused on scientific inquiry and the structure of the scientific disciplines. The impetus was the launching of the Soviet satellite

Sputnik—an event which proved to be a spur to massive American efforts to regain supremacy in superpower competition. Scientific agencies, backed by substantial government funding, called for an educational initiative which would produce more scientists and engineers. Thus discipline-based programs such as BSCS , CHEM Study, and PSSC were developed, and quickly became accepted and adopted in many countries, including Canada. To the extent that these programs increased the supply of scientists and engineers up to and beyond the number needed by society, they were successful. Even so, it was evident that twenty years of "structure of the discipline" science curricula had had relatively little impact on actual teaching practices (Welch, 1979).

Through the 1970's and early 1980's there were increasing calls for change in science curricula from a number of sources. It was increasingly apparent to science educators that the curriculum goals of the post-Sputnik era were no longer appropriate, that changes in science, society, and the earth itself demanded new goals for science education. Paul Hurd (1975) called for educators to "realign the teaching of science with social realities." Perspectives on the nature of these new social realities varied. For some, especially those aligned with governments, industry, and business, there was a utilitarian view of social needs as the demand for workers who could function well in the new technological workplace, in order to ensure economic growth and competitiveness (e.g. Science Council of Canada, 1984 , American Association for the Advancement of Science, 1989). For some science educators, the new social reality consisted of the growing number of science-related social problems and issues : the human population explosion, the energy crisis, food production, pollution, waste management, nuclear energy, and so on (Aikenhead, 1980; Bybee et al., 1980; Hofstein & Yager, 1982; Hurd,1975). There was also a growing consciousness

among science educators that "spaceship earth" was threatened—not only human society, but all living organisms and even the physical environment were at risk.

The changing society stimulated a rethinking by science curriculum writers of *who* science education was for (see figure 2). The "structure of the disciplines" curricula of the 1960's were essentially vocational preparation for scientists and engineers—a science education for the small group (5-20%) of students who would pursue further education or careers in science-related fields. The vast majority of students were not served well by the conventional discipline-oriented science courses. Many chose not to take science courses, while a substantial number of those that did found them abstract, difficult, and irrelevant to their lives. Titles of articles and reports such as " Science for all" (Fensham, 1986), "Science for every student" (Science Council of Canada, 1984) and "Science for all Americans" (American Association for the Advancement of Science, 1989) illustrate a trend among science educators and other interest groups to move away from an elite "science-for-the-few" curriculum to an emphasis on educating for a scientifically literate society.

This then, is the thinking behind the STS movement in science education. An accelerating rate of change in society, brought about by a highly technologized society and by human population growth with its attendant environmental and social problems, has resulted in a major rethinking of the goals of science education for our times. There is movement among science educators towards the personal and social goals of general education, which were lost sight of during curriculum reforms of the 1960's (Bybee, 1987), towards goals emphasizing the knowledge, skills, and attitudes which citizens

Figure 1: Curriculum Change: Discipline-Based Science to STS

[Based on Bybee, (1987); Fensham, (1986); Hurd, (1975)]

	<u>Conventional Science</u>	<u>STS Science</u>
Who is it for?	• future scientists, engineers, other science-related careers	• for all students, as future citizens
Perceived societal needs	• more scientists & engineers	• informed decision-makers
Perceived personal needs of students	• development of reasoning & inquiry skills	• intellectual, moral, social development
Typical Goals	• acquire science concepts, principles, theories • develop scientific process skills	• acquire science concepts, principles, theories relevant to societal problems • scientific literacy • personal/social impacts of science & technology • develop technological problem-solving skills • develop societal decision-making skills
Science Disciplines	• separate: "biology," "chemistry," "physics"	• integrated or interdisciplinary ("science")
View of Science	• objective, value-free, cumulative (<u>romantic-idealistic</u> view)	• value-laden, subjective, revolutionary, tentative, socially constructed (more <u>authentic view</u>)
Teaching strategies	• lecture • class "discussion" • lab exercises	• lecture (less) • small group discussion • small group decision-making activities • role-playing, debates • technological problem-solving activities • projects: societal issue • lab activities: more open-ended
Evaluation	• objective: tests, assignments, lab reports • based on "right answers"	• subjective, holistic (group work, decision-making, projects, problem-solving)
Teacher's Role	• dispenser & controller of information (<u>"sage on the stage"</u>)	• facilitator of broad range of experiences (<u>"guide on the side"</u>)

of the future will need to cope with a high-tech workplace, and to make sound decisions on urgent science-related social issues.

Approaches to Science-Technology-Society Curriculum

Science-technology-society education deals with the interactions among science, technology and society. This gives possibilities for several different interactions and emphases: science, science and technology, technology, science and society, technology and society, for a start. Which are most important? Which aspects of science, of technology, of science and society, should be emphasized? How should an STS curriculum be organized?

Ziman (1980) has identified seven different approaches to STS education. The *relevance/applications* approach implies that "valid" science is traditional science content with relevance to economic, political, or social issues. The *historical*, *philosophical* and *sociological* approaches emphasize different aspects of the nature of science: the advancement of scientific knowledge, scientific communities and institutions, the nature of scientific knowledge, personal and social dimensions of scientific research, and so on. The *vocational* approach focuses on the personal and social dimensions of science and technology which directly apply to the high-technology workplace, and to careers in science and technology. In the *interdisciplinary* approach, subject matter is integrated and related to socially important issues such as the environment, or energy. The *problematic* approach uses pressing social problems as its starting point and main focus, and attempts to illustrate the role of science and technology in these problems. Ziman suggests that there is no best approach—each has its merits and deficiencies—although some sort of balance among them is necessary for an STS curriculum.

Hofstein and Yager (1982) are among those that advocate the problematic approach. They propose that the science curriculum be built around social issues, so that science and technology content would be selected for its relevance to decision-

making and social issues. This approach has been roundly criticized by traditionalists (Kromhout & Good, 1983; Good et al., 1985) who see the province of science education strictly as discipline-based scientific knowledge and reasoning skills as defined by scientists, and who fear manipulation of the science curriculum by "social activists." STS supporters such as Bybee (1987) feel Hofstein and Yager's problematic approach is incomplete without adequate scientific and technological knowledge, personal and social applications of that knowledge, and reasoning and inquiry skills in scientific and technological contexts.

The Science and Technology in Society (SATIS) curriculum project in the U.K. seems to be an example of Ziman's *relevance/applications* and *vocational* approaches. Built around applications of science and technology and social issues relevant to the worlds of work and citizenship, and intended for 14-16 year olds, the units have titles like "Air Pollution: Where does it come from?", "Chemicals from Salt," and "The Technology of Toilets," and involve teaching strategies such as discussions, role-playing, decision-making, problem-solving and surveys.

A different tack is taken by the American Association for the Advancement of Science (1989) in its Project 2061. It indicates that "scientific literacy—which embraces science, mathematics, and technology—has emerged as a central goal of literacy." This influential group advocates a relevance/applications science curriculum with traditional science content, the nature of science, the interactions of science, technology and mathematics, but makes scant mention of society or societal issues.

Bybee (1985, 1987) argues that the STS theme (interactions of science, technology and society) is only part of science education, and suggests a conceptual framework for science curriculum development consisting of three essential goals: (a) the acquisition of *knowledge* of science and technology concepts which have personal,

cultural, and civic significance, (b) the development of scientific and technological *inquiry skills* through problem-solving and decision-making, (c) development of *ideas and values* about local and global issues that involve the interaction of science, technology and society.

Doug Roberts (1982a) has presented an alternative way of making sense of the curriculum diversity of STS education. He proposes the concept of a *curriculum emphasis* as "a coherent set of messages to students about science," under which lie specific curriculum goals. Roberts and others have used the curriculum emphasis concept in developing an intermediate STS curriculum in Ontario. They clustered a number of broad aims into three curriculum emphases, which are similar to Bybee's (1987) three themes: "Structure of Science," Scientific Skill Development," and "Science and Society." The curriculum emphases were associated with individual units of instruction in a grade 7-8 program so that two out of the six units incorporated each emphasis in a systematic way, giving, at least on paper, a balanced approach to addressing all the aims of this STS program. The notion of the "curriculum emphasis" has also been utilized in the development of the 1990 Alberta Junior High School Science Program, whose authors were heavily influenced by Robert's work.

The foregoing discussion should give some general insights into the origins, nature, and diversity of STS curriculum, and the STS issues being disputed by science educators in the mainstream science education literature. We have seen that the STS movement originated in changing perceptions of social needs and priorities in the face of widespread societal changes wrought by the effects of modern science and technology. A more detailed and critical investigation of STS curriculum issues will be pursued in the analysis of the Alberta Junior High Science Program in Chapter IV.

Research on Science and STS Curriculum Change

Next we turn our attention to the literature on curriculum change in the science classroom, and especially to the limited amount of research on STS curriculum. How have science teachers experienced the last few generations of curriculum changes? In the wake of the major American and British science curriculum projects of the 1960's and 1970's, a number of implementation studies were carried out, with similar results to those of the bulk of such studies. For instance, in a study of the classroom use of BSCS curriculum materials by six different teachers, Gallagher (1967) concluded that given the diversity of interpretations and adaptations by teachers, "there is no such thing as a BSCS curriculum presentation in schools." Likewise, in a review of twenty years of U.S. science curriculum development Welch (1979) asserts that: "in spite of the expenditure of millions of dollars and the involvement of some of the most brilliant scientific minds, the science classroom of today is little different that of twenty years ago." Macdonald and Walker (1976) give a similar account of the development of the Nuffield Science programmes in the U.K. They found that while the curricula had considerable impact at the policy level, they had much less effect on changing practice in science classrooms. Nuffield physics teachers, for instance, "distorted the message" of the Nuffield program by converting discovery methods to didactic teaching, and by adapting materials designed for active participation to passive rote learning. Studies such as these, conceived in the technological perspective, served to demonstrate the stability of teaching practice in science classrooms, while doing little to promote understanding of the nature of this stability.

The case studies of Stake and Easley (1978) and Olson and Russell (1984), discussed previously, reveal rich details about the intentions and lifeworld of science teachers, although they do not focus specifically on curriculum change. Olson and

Russell , however, do suggest that their work "will yield some hint.of the possible consequences of upsetting the delicate balances teachers create to cope with teaching as an occupation"(p. 16).

Recent empirical studies on the implementation of science curricula are relatively few in number, especially studies dealing with STS implementation. Two recent studies involving STS curricula illustrate a technical orientation to implementation. Zoller et. al. (1990) surveyed several hundred British Columbia high school students regarding their attainment of STS goals related to the nature of science, and societal decisions. The items on the survey involved such concepts as the social responsibility of scientists, and the role of moral values in science. Comparing the outcomes of students who had been involved in an STS program with those that had not, the authors found that for three out of four items the STS group performed better than the "control" group, and concluded that the goals of STS education were attained, i.e. practice had lived up to plan. The assumption in a study of this type seems to be that the assessment of a limited range of goals with objective written tests is equivalent to successful implementation, and that the practice which lies between the curriculum-as-planned and student outcomes is a "black box" which need not be taken into account.

In a recent case study, Mitchener and Anderson (1989) interviewed and observed fourteen experienced junior high science teachers in schools which had recently adopted an award-winning STS program with a strong cooperative learning emphasis. Overall, relatively little change in practice occurred. All the teachers in the study were strongly oriented to the "preparation ethic." They were concerned about the paucity of content in the program, and all made some effort at "beefing it up" (although the degree of content addition varied according to the teachers' values). The teachers

consistently had difficulty with the facilitator role and with the uncertainties of group work and subjective evaluation.

About a third of the teachers "accepted" the program with minor modifications. The focus on group skills, decision-making and relevant applications was acceptable to these teachers because their beliefs and values were already compatible with those of the program, and because, for them, the level of student interest and motivation outweighed any drawbacks of the course. A third of the teachers in the Mitchener and Anderson study made significant alterations to the program. Although they accepted the beliefs and values of the course, they felt uncomfortable and inadequate with the instructional strategies, content and evaluation methods. They tended to add considerable traditional content, and to use more structured didactic strategies which alleviated their frustration with subjective evaluation. Five out of the fourteen teachers reportedly rejected the course entirely. This group repudiated the values and beliefs of the program, its content and its methodology. They valued (and taught in their classes) traditional academic science content, a structured approach, traditional lab work, and a "solid foundation" for future study. Their prestige as discipline-based science teachers was threatened by the low status STS program, and they were strongly driven by the preparation and socialization ethics.

The authors conclude that the classroom teacher is the key figure in determining the success or failure of a new STS curriculum, but possibilities for planned change were limited, without changing the beliefs and values of teachers. Their work supports many of the implications of classroom life discussed earlier. This is, however, a relatively superficial and simplistic study, in its classification of teachers into three categories relative to their "adoption" or otherwise of the curriculum, in its underemphasis on situational, historical, or political context, and its failure to

acknowledge the teacher's role in curriculum development, the nature of the teaching act, or the complexity and dialectical nature of the teacher's lifeworld.

Summary and Conclusions

So far I have given an account of the literature relevant to the central question of this study : how do teachers experience a science-technology-society curriculum change in their professional lives? We have seen that the dominant mode of thinking about, practicing and researching curriculum change—technical curriculum implementation—strongly misconceives the purpose and nature of schooling, as well as the nature of the teaching act. I have suggested a reformulation of teaching as practice, rather than technique, with teachers conceived as free agents deliberating and making wise decisions about what is the "good" for their students and not as efficient technicians. There seems to be a consensus among researchers that the simultaneous pressures and limitations inherent in classroom life produce ambiguities, uncertainties, and tensions which teachers tend to resolve by practices which give a measure of stability to classroom life. I have also tried to clarify the origins and nature of the science-technology-society curriculum movement, and to show that the research on curriculum change in science education is consistent with the curriculum change literature generally, in portraying the stability of science teaching despite mandated changes in in curricula. Finally, I contend that little empirical research on STS curriculum change has been conducted, and that the research conducted to date has offered a fairly narrow perspective on classroom life. The literature demonstrates a need for inquiries into curriculum change which can advance our understanding of the implications of science-technology-society or other science curricula for the lifeworld of classroom teachers.

CHAPTER 3

The Alberta Junior High Science Program

Rationale

Curriculum theory must address the question "what counts as knowledge?" in a particular subject area (Cherryholmes, 1982). This chapter of the study attempts to answer that question for Alberta junior high science with an account of the kinds and sources of knowledge represented in its content, a critical scrutiny of the underlying educational, philosophical, and ideological assumptions, and a clarification of its ethical commitments. A curriculum document, such as the Alberta Junior High Science Program of Studies, is relevant to an interpretive study of teachers' classroom experiences in two ways.

Firstly, as part of the context of classroom life for teachers and pupils, it defines one set of important parameters (Goodson, 1991), and suggests direction for teaching and learning within those boundaries by selecting certain priorities, emphases, and subject matter. Secondly, the examination of a syllabus can reveal insights into the ideological, political, and economic forces at work in the development of a curriculum at a particular time and place, with implications for how those pressures might impinge on teachers. The analysis will also provide an opportunity to sketch out the researcher's own curriculum perspective—intentions, biases, assumptions, beliefs, and values—in order to juxtapose this against the teachers' perspectives in a later part of the study. Moreover, this investigation of a curriculum addresses a gap in the STS literature. Relatively little research has been published which critically reflects upon science-technology-society curriculum documents or attempts to clarify the implications for the STS curriculum movement of the ideological contest for curriculum taking place in society.

The Researcher's Curriculum Framework and Criteria for Analysis

Each author brings particular intentions, commitments, biases, values and frames of reference to curriculum research. In this study, I am working within an interpretive framework that also incorporates a critical perspective. In other words, my commitment is to not only pose pertinent technical questions, but to focus on questions of meaning and morality, as well as on related questions of interests and power. The postpositivist assumptions and beliefs that underpin this framework come not from casual academic expediency, but from a deep conviction borne of several years of reading and reflection, from a person with a scientific background, an ex-junior high teacher and concerned parent, who has rejected once firm, but unexamined beliefs and values. The analysis is guided by one overall consideration: "what is in young people's best interests"?

The evidence used in the analysis consists of the Alberta Junior High School Program of Studies (1990), other relevant Alberta Education publications, documents representing the views of stakeholders in the Alberta curriculum debate, and literature on STS curriculum, constructivist psychology, and the curriculum debate in the U.S and elsewhere. An attempt is made, in selecting excerpts from documents, to strike a balance between a representative and a comprehensive treatment, while providing sufficient text for readers to form their own judgements. More attention is focused on the introductory sections of the program than on the specific content details of each unit, in order to provide a manageable discussion of curriculum issues of importance.

The program is analyzed firstly on the basis of consistency with the literature on STS education and constructivism, and with the Canada Science Council's Report 36 (1984). Secondly, the internal consistency of philosophy, goals, emphases, form and content is examined. Thirdly, the implications of key elements of the document for

teaching and learning are explored, and lastly, the significance of the social-political context of an ideological struggle for the curriculum in North America and internationally is considered.

Background to the Program

The Pre-1990 Alberta Junior High Science Program.

Since frequent reference will be made later in the study to the "old program," a brief description follows. The 1978 junior high science program in Alberta was a revised version of a 1974 discipline-based program, in which students studied biology in grade 7, earth science in grade 8, and physical science in grade 9 (Alberta Education, 1978). Alberta Education's own Secondary Education Instructional Program Review (1987) identified a number of deficiencies in that program, including: insufficient recognition of learner developmental levels, failure to incorporate a range of program goals into the course outline, teachers' perception that a list of concepts or facts was the core of the program, little Canadian content (the recommended texts were American), no clear direction for intellectual development, no emphasis on societal issues, and so on; it was, in effect, a traditional content-oriented and discipline-based program.

Origins of a New Junior High Science Program.

In 1984 the Science Council of Canada called for a realignment of science education stressing the interactions of science, technology, and society in a Canadian context. Around the same time, Alberta Education (1985) mandated changes in secondary programs "toward preparing students to live in a changing and complex technological society." Based on this policy, on the Science Council's Report 36 (1984), and other reports, Alberta Education began developing a new junior high program emphasizing science, technology, and society connections. The program

became mandatory for about 33,000 grade seven students in 800 schools across Alberta in the fall of 1990.

The Subject Matter

Form and Organization of the Program of Studies

As a preliminary step, it may be useful to briefly consider the form and organization of the program of studies, with a view to subsequent discussion of its meaning. The program of studies is a twenty page document consisting of four sections (Alberta Education, 1990). The *Program Rationale and Philosophy* (2 pp.) describes the basic aims of secondary and science education, and the developers' orientation to learning, STS education, and scientific literacy. *General Learner Expectations* (3 pp.) identifies the program's three major curriculum emphases: (1) Nature of Science, (2) Science and Technology, and (3) Science, Technology, and Society, and lists the more general attitudes, skills, and concepts associated with each curriculum emphasis. The *Specific Learner Expectations* outlines the organization of each grade level into six units, describes the required/elective/optional content policies, and lists specific learning objectives—attitudes, skills, and concepts—for each of the six units in grade seven (14 pp.). Finally, *Learning Resources* identifies the two approved textbooks (1/2 pp.).

The first five pages—rationale and philosophy and general expectations—constitute what Goodson (1991) calls "legitimizing rhetoric for schooling" which bears the symbolic function of publicly legitimating certain curriculum intentions. The subsequent fourteen pages of expectations or objectives have the practical function of communicating to administrators, teachers, textbook writers, and examination designers which specific knowledge counts for junior high science. However, as I will show, there is a conflict between the legitimating rhetoric and the specific learner

expectations of this document, arising from contradictory underlying curriculum orientations and philosophies.

Science Curriculum Issues and the Program

Science-Technology-Society Education.

In the recent past, science courses in Alberta (e.g., Alberta Education, 1978), and elsewhere have been dominated by the academic tradition of school curriculum, characterized by a focus on content and theoretical knowledge, and legitimated by university subject area communities (Goodson, 1983). What counted as scientific knowledge for secondary pupils was primarily determined by curriculum "experts" and university professors in a particular science discipline. Although it retains some allegiance to the academic tradition, the 1990 Junior High Science Program marks a movement towards two alternative curriculum traditions identified by Goodson (1983): the pedagogic and the utilitarian.

The pedagogic tradition of subject matter stresses personal, social, commonsense knowledge, and is centered on how pupils learn. It sees knowledge more as a vehicle for young peoples' growth and development than as a ladder towards success in a particular profession or vocation. The utilitarian tradition deals with practical knowledge and skills potentially useful in subsequent employment in industry and commerce, or with practical relevance to everyday life (Goodson, 1983).

Within the STS movement, various interpretations exist regarding what constitutes worthwhile knowledge in science-technology-society, and whether pedagogic, academic, or utilitarian concerns should take precedence. The Alberta Junior High Science Program, for instance, contains elements of all three curriculum traditions. For instance, the program rationale and philosophy outlines the curriculum developers' basic orientation to science, technology and society:

The content of the program is presented in contexts that illustrate the development and application of science. Frequent attention is given to the processes by which scientific knowledge is gathered, largely by involving students directly in the practice of scientific inquiry. Significant attention is also given to other contexts of science, particularly the application of science to the solution of practical problems, and an examination of the implications of science and technology with respect to personal and social impacts. The processes of problem-solving and decision-making are given direct attention in learning activities: students are involved in ways that stimulate their critical and creative thinking skills (Alberta Education, 1990, p.1).

The emphases on the nature and applications of science, science processes, personal and societal implications of science and technology, and decision-making are fairly typical general aims for the STS movement in Canada and the USA (Aikenhead, 1980; Bybee, 1987; Hurd, 1975; Science Council of Canada, 1984) which suggest a blending and legitimating of all three of Goodson's curriculum perspectives.

The STS flavor of the Alberta Junior High School Science Program is further indicated by the use of "curriculum emphases" (Roberts, 1982a). The program has three major areas of emphasis: (1) Nature of Science, (2) Science and Technology, and (3) Science, Technology and Society. Subject matter is organized through the incorporation of knowledge, skill, and attitude outcomes within each emphasis (figure 2). For example, the "Nature of Science" emphasis, which includes attitudes relating to the natural world and scientific values, science inquiry skills, and concepts concerning the nature of scientific knowledge and scientific activities, is principally academic in its orientation (since it focuses on the subject matter of science), and secondarily pedagogic and utilitarian. The "Science, Technology, and Society" emphasis on the other hand, seems to be primarily pedagogic, and the science and technology would find its legitimization mainly in utilitarian arguments. If the overall emphasis of the program is observed, we find that, at the grade seven level, four units incorporate a

Nature of Science emphasis, and one unit each contains a Science-Technology or Science-Technology-Society emphasis.

Figure 2: Alberta Junior High Science Curriculum Emphases
(Alberta Education, 1990)

1. NATURE OF SCIENCE

- *attitudes*: positive attitudes towards the natural world; scientific attitudes—honesty, open-mindedness, critical-mindedness, and so forth.
- *science inquiry skills*: questioning, proposing ideas, designing experiments, gathering, processing and organizing data.
- *concepts*: nature of scientific knowledge, scientific explanation, and scientific inquiry.

2. SCIENCE AND TECHNOLOGY

- *attitudes*: appreciation and awareness of technology and technological problem-solving.
- *technological problem-solving skills*: understanding the problem, developing, carrying out and evaluating a plan.
- *concepts*: nature of technology, interactions of science and technology, nature of technological problem-solving.

3. SCIENCE, TECHNOLOGY, AND SOCIETY

- *attitudes*: appreciation of decision-making, contributions and limitations of science and society to decision-making, different perspectives on decision-making.
- *decision-making skills*: identifying issues and alternatives, researching issues, reflecting and deciding, taking action.
- *concepts*: relationships of science and technology, and societal decision-making, nature of societal decision-making, effects of science and technology on society.

Then, over the three years of the junior high program, unit emphases break down as follows: nature of science, 50%; science and technology, 33%; science, technology, and society, 17%. The balance of emphasis, in practice as opposed to rhetoric, is therefore towards the nature of science, a more traditional academic context, with a secondary stress on technology, and a relatively minor weighting on science-technology-society connections. By way of comparison, the Science Council of Canada's Report 36 (1984) recommended that for grade 7-9 level, 33% of the time in science courses be devoted to STS connections, although for the U.S.A., Bybee

(1987) reports that according to surveys of various groups 15% was the minimum recommended amount of time.

When one examines the content of the science-technology-society units—microorganisms and food supplies (grade 7), consumer product testing (grade 8), and environmental quality (grade 9)—although there is some discussion of socially important issues such as pollution and waste disposal in the environmental quality unit, it is debatable whether the safety of food supplies and consumer products in Western Canada is one of the socially compelling issues that young people today are concerned about and will have to grapple with as tomorrow's decision makers (cf. Bybee, 1987). Two of the three S-T-S units are the last units in the year's work, a location which often compromises the amount of time and energy devoted to a topic. The Science Council of Canada (1984) recommended that the emphasis on science-technology-society connections be "a matter of top priority for all levels of schooling" (p. 38) to promote "science for the informed citizen" (p. 39). It is evident that, as far as content goes, Alberta Education has given the S-T-S emphasis, and possibly pedagogical concerns, somewhat less than top priority in its Junior High Science program.

Another Science Council recommendation is the introduction of technology education to secondary schools, based on the utilitarian concern that education prepare students "for their participation as creative contributors to the world of work" (p.43). Here, Alberta Education has followed the Council's call for a technology component for science courses which includes both knowledge of technological products and hands-on experience with technological problem-solving. One-third of the units have a science-technology emphasis, including a diversity of topics such as structures and design, energy and machines, growing plants, fluids and pressure, heat energy, and electromagnetic systems. Each unit integrates practical problem-solving activities with

relevant scientific background knowledge and knowledge of technological materials, such as concrete, bridges, insulation, fertilizers, and electrical circuits. The actual content seems to be fairly appropriate not only from the point of view of its pedagogical relevance to the experience, capacities, and interests of 12-15 year-olds, but also in terms of its utilitarian applicability to their everyday lives, and to the world of work.

Integrated Science.

One implication of both the pedagogic academic tradition (Goodson, 1983) and S-T-S education is the use of an interdisciplinary approach. "Interdisciplinary science," often called "integrated science," refers to subject matter in which the various science disciplines are taught in an integrated way (Blum, 1991). The pedagogic tradition argues that rigid subject boundaries are barriers to effective learning and promote didactic teaching as well as passive student roles (Goodson, 1983). Support for integration also comes from the learning psychology of Gagné, Bruner, and Piaget, which implies that integrated science can augment the learning and transfer of concepts, lends itself more to the concrete experiences which younger secondary students need, and is generally more appropriate to the learning needs and capacities of children (Blum, 1991). From the standpoint of S-T-S education, it is argued that discipline based science courses are too fragmented and restricted to deal effectively with science-related social issues (Hurd, 1975). Academically oriented epistemological and methodological arguments are also brought into play to support an interdisciplinary STS curriculum, namely that science disciplines share common conceptual structures, universal laws and similar methods of empirical inquiry (Blum, 1991; Hurd, 1975).

Approaches to integrating science curricula vary in the method, range and degree of integration of the separate disciplines. Integration methods involve the use of themes, common concepts, STS issues, or problems, while the range of integration

varies from the inclusion of two closely related sciences (e.g., chemistry and physics) to all of the natural sciences. The disciplines may be amalgamated, in which a topic or issue is approached within a unit in an interdisciplinary fashion, or combined, where major units are organized around the teaching of a topic from a particular discipline (Blum, 1991). In its Junior High Science Program, Alberta has chosen the combined approach. This constitutes a milder departure from the academic tradition for developers, teachers, and students than other alternatives, since the content of each unit is confined to a particular science discipline. In the overall grade 7-9 program, for instance, there are six units with biology content, six physics units, three chemistry units, and two earth science units, but only one unit (Structures and Design in grade 7) that contains no traditional academic science content at all. If the conceptual content of the program is surveyed, many of the topics are similar to those of the 1978 junior high program (e.g. characteristics of living things, ecosystems, heat and temperature, energy, chemical properties, erosion, earth's crust), although there seems to be a greater emphasis on learning concepts in contexts that would be familiar to students. Methodological integration is brought about through the generic skills contained in the three STS emphases: science inquiry skills, technological problem-solving skills, and decision-making skills. For example, each of the nine units with a nature of science emphasis in the program, regardless of discipline, features the identical science inquiry skills. Although this fulfills the requirements of skill integration, at the same time (as we will see later) it also tends to oversimplify the presentation of modern science.

Conceptual integration of the STS emphases within the whole program was a challenge for the developers. Any attempts, for instance, to integrate concepts such as "scientific knowledge is cumulative and subject to change" or "interpretations and conceptual inventions...are theoretical in nature" are not apparent in the individual

nature of science units. The content of each unit is more or less academic science discipline material which, although well-chosen considering the intended learners' interests and capacities, lacks any explicit integrating principle such as a theme or issue to which broader concepts about science might be attached. Thus it is left to interpreters of the curriculum—textbook writers or individual teachers—to explicitly integrate concepts.

Scientific Literacy.

Associated with the STS movement is the concept of scientific literacy. The shift in goals from science for a small cadre of future scientists or engineers, to science for all students was generated by the astonishing pace of change in a society dominated by science and technology. A basic understanding of science that enables not just the scientist or technologist, but anyone to make informed decisions and function in society is referred to as "scientific literacy" (Klopfer, 1991). The knowledge needed to function as an informed decision-maker has several dimensions. Miller (1983) concludes that (a) the norms and methods of science, (b) cognitive science knowledge (basic science concepts), and (c) attitudes towards organized science (including knowledge about STS interactions and interest in science) constitute the substance of scientific literacy. To this list, Klopfer (1991) adds the ability to apply scientific knowledge in everyday life. In Canada, the Science Council (1984) proposes four aims for scientific literacy, roughly corresponding to the knowledge dimensions outlined above: (i) informed participation in a technological society (knowledge of STS interactions) (ii) preparation for further science studies (science concepts including everyday applications and nature of science) (iii) preparation for the world of work (technology and problem-solving) (iv) intellectual and moral development of the student (science inquiry skills, rationality, critical thinking, ability to explain and understand

their environment). In the above aims for scientific literacy can clearly be seen the legitimization of the three perennial curriculum orientations: preparation for science studies (academic), preparation for the world of work (utilitarian), and informed participation/intellectual and moral development (pedagogic). The main distinction between the Canadian conception of scientific literacy and its U.S. counterparts seems to be a greater emphasis on technology education in Canada.

Scientific literacy appears in the Alberta J.H. Science Program as a brief reference at the end of the philosophy and rationale section. It states that "in broad terms, the intended outcome of the secondary science program is the development of a scientifically literate citizenry" (Alberta Education, 1990, p.2). Eight behaviors indicative of a scientifically literate person are then listed, corresponding roughly to the aims described in the Science Council's Report 36 (1984) and elsewhere in the literature. These include an understanding of science and science processes, the ability to use scientific processes, the application of science to everyday problems, the recognition of science-technology relationships and limitations, an awareness of science and technology in a social context, and an interest in science and technology. What appears to be lacking is a discussion of the meaning and importance of scientific literacy, a sense of the priority of the relationships between the eight different aims of scientific literacy, or an explicit attempt to relate scientific literacy to the stated aims of secondary science education or the general or specific learning outcomes which follow. Furthermore, there is no other reference to scientific literacy in the written curriculum. While scientific literacy as defined in the program is generally consistent with the stated aims for education ("making informed choices", p.1), the aims for science education ("understand and interpret the world in which they live"; "the intelligent and responsible application of science and technology, p.1) and the knowledge skills and attitudes

associated with the three curriculum emphases described earlier, it has the appearance of an "add-on." The treatment and location of scientific literacy suggests that its inclusion is perhaps an afterthought, rather than a well thought-out and high priority goal.

The Nature of Science and Technology.

An integral part of the rationale for studying science-technology-society connections is the need to equip students with an understanding of the nature of science and technology. An instance of this is the Science Council of Canada report (1984), which stresses the importance of future citizens and decision-makers learning "not only the traditional basics of language and mathematics, but also the *new* basics of our contemporary culture: science and technology" (p. 9). The report recommends "presenting a more authentic view of science" to students, which "should include historical, social and philosophical dimensions" (p. 37). The Science Council perceives that science textbooks present an "overly standardized and simplified" version of the scientific enterprise, and should instead discuss such topics as the effects of the social and political climate on scientific activities, the interplay between science and technology, and the limits of science. The argument is that this would provide a more realistic view of science so that tomorrow's scientists (and all citizens) could "base their political and social decisions on a sound knowledge of how science and technology function" (p.38). In addition, the report recommends the introduction of technology education, which would "promote an understanding of the problem-solving nature and purpose of technology and an awareness...of its impact on Canadian society" (p. 42).

What is problematic in these recommendations, and in the inclusion of a realistic view of science and technology in science courses in general, is *which* view?

Numerous conflicting conceptions of the nature of science and technology exist in the

literature, representing divergent underlying philosophies and ideologies. Accounts of science range from naive inductivism and positivism on one hand, to Feyerabend's anarchism or quantum philosophy on the other (Chalmers, 1982). Some views accept the social, cultural and political milieu of science and technology without question, but others mount a critique of the values, assumptions and beliefs associated with modern science and technology.

With this diversity of versions of "authentic science and technology" in mind, let us now proceed to a scrutiny of the Alberta junior high science program of studies for its particular conceptions of the nature of science and technology. Much of the portrayal of science is straightforward. Neither "science is a disciplined way to develop explanations for natural phenomena," or the contention that science is characterized by "observable data that can be repeatedly demonstrated in various places, at different times, by different investigators" (p. 3), for example, would arouse much controversy. However, "scientific knowledge is cumulative and subject to change" is perhaps oversimplified and out of date. Kuhn (1970) has long since refuted the notion that scientific knowledge is a linear accumulation of facts and theories. Although knowledge does accumulate within a particular paradigm or worldview, according to Kuhn, paradigms in science change, and with the change, old theories and even some facts become obsolete, rather than accumulating.

Equally, "subject to change," while possibly qualifying "cumulative," understates the case for the tentativeness and uncertainty of scientific knowledge. This is an important issue in STS education, because the public needs to understand that decisions will often need to be made on the basis of scientific knowledge that is ambiguous and controversial, especially when dealing with complex systems such as the biosphere or human health. Scientifically literate citizens must realize that science

involves probability, not certainty, and that the "proof" often demanded by industrial interest groups, for instance, is just not possible. For this reason, "subject to change" does not go far enough to provide the necessary understanding of this issue.

Another significant aspect of science presented in "Nature of Science Concepts" is "experimentation (scientific inquiry) as a means to support, modify, or reject proposed ideas about natural phenomena" (p. 3). This is probably correct as far as an idealized version of science goes. However two qualifications have to be made. To begin with, along with the science inquiry skills model ("1. questioning, 2. proposing ideas, 3. designing experiments, 4. gathering data, 5. processing data, 6. interpreting data" [p.3]) it equates scientific inquiry with the experiment. Mayr (1989), among others, makes a strong argument that most accounts of science concentrate on the physical sciences, in which experimentation, dealing with relatively simple systems, has been the dominant method. However, a great deal of scientific work now and in the past, especially in the biological and earth sciences, does not and can not involve controlling and manipulating variables. In these fields, descriptive and comparative methods are commonly or even exclusively used. In fact, if the science teacher were to use current newspaper, magazine and TV accounts of science as a basis for identifying "significant aspects of the scientific enterprise," a major part of the work described in social-issue related fields like ecology, atmospheric science, and human health would be descriptive or comparative.

The second point regards the notion of " (scientific inquiry) as a means to support, modify, or reject proposed ideas about natural phenomena." Again, this is true up to a point, but brings up the problem of oversimplification and standardization. It perpetuates the positivist myth of the "objectivity" of science, by incorrectly suggesting that scientific ideas are supported or rejected based only on the results of

inquiry, rather than on human values and emotions. There is abundant evidence (Kuhn, 1970; Bronowski, 1965) that, as in all areas of human endeavor, ideas in science are linked inextricably with values, feelings, and emotions, and these can sway a scientist's (or citizen's) acceptance or rejection of those ideas regardless of the evidence. As Kuhn points out, scientific theories have a large amount of inertia associated with them. Scientists with a lifelong stake in a particular idea are naturally reluctant to reject an idea associated with their career, reputation, and success. The history of science often shows (Kuhn, 1970) that a scientific theory abundantly refuted by the evidence may persist, to finally die out only when its supporters retire or themselves pass away.

A final example of the view of science given by the program is "interpretations and conceptual inventions are theoretical in nature" (p. 3). Although it is not clear, the intention appears to be setting "factual knowledge" against "theoretical knowledge." As before, it is acceptable, up to a point, to acknowledge that data are one thing, and ideas or generalizations about data are another. Scientific papers, for example, separate the "results" section from the "discussion" section for that reason. But the consensus among philosophers of science is that facts are "theory-laden" (Hacking, 1983). This is not to say that all facts are dependent on and intertwined with theory, but that many scientific "facts" are only observable by virtue of the assumptions of a particular scientific theory. Quantum physics, with its wave-particle conundrum's, is a good example (Horgan, 1992). The sharp distinction between theory and observation suggested by the program of studies is consistent with a positivist perspective, which requires "objective facts" drawn from a real world which is out there on which to base its propositions, a perspective that has been thoroughly rejected by mainstream philosophy of science.

What is also missing in the account of science in the Alberta program is any indication of the purpose of science. For some scientists, philosophers, and educators, science is a search for knowledge, a quest to understand the world and universe they live in, driven by curiosity. For others, science is viewed instrumentally, with scientific knowledge seen as a means to predict and control nature to suit human purposes. This is not only a philosophical issue, but also a political and practical one with implications for how science students, tomorrow's decision-makers, see science in society. Many disputes about the desirability of certain strands of scientific research, for instance, center on the issue, "what good is it"? If the public conceives science only instrumentally, then scientific inquiry would tend to be skewed towards applied research with clearly demonstrable public outcomes and whichever social economic or political agenda is current. Of course, much science, present and historic, has fit this description. But the continuation of science as part of the culture of inquiry, as "basic research" motivated by individual scientists' desire to understand some obscure corner of nature with no immediate economic benefit, depends on a public that accepts without qualification science-as-finding-out, in addition to science-as-finding-applications.

Similar arguments apply to the junior high science program's treatments of technology and science-technology-society interactions. Much of the content is straightforward and compatible with the literature on technology (Burke, 1978; Gendron, 1977; Susskind, 1973). For instance this is how technology is defined: "technology is a process of solving practical problems,....(which) includes products and processes...to serve human needs" (p.4). Likewise, interactions of science and technology are represented accurately: "the development of new technologies may open up new areas for scientific investigation.... solving technological problems frequently involves the application of scientific knowledge....technologies arise from common

practices and traditions as well as from the creative applications of scientific knowledge" (p.4).

Furthermore the program conveys a fairly realistic account of how technology operates in western society. The problem-solving process, the syllabus suggests, consists of : "(a) understanding the problem, (b) developing a plan, (c) carrying out the plan, and (d) evaluating the design and the planning " (p. 4). There are some hints about how the technologist might take interactions with society and the environment into account: " appreciation of good design with consideration to function, safety, aesthetics, and environmental effects" (p.4). But is this enough, considering the dramatic way in which technological problem-solving processes have shaped and continue to shape society? What is unaccounted for in this problem-solving approach is what is too often absent in its real-life counterpart: the ethical component. Although developing a plan involves " design as a means to support, modify, or reject alternative ideas for solving the problem" and "critical thinking in evaluating potential solutions and suggesting improvements" (p.4), there is no element of critical reflection on the desirability of the task itself, except in terms of its most expedient solution. In other words, as Franklin (1990) has it, the "logic of technical production" is being promoted, instead of the "logic of compassion, obligation, or ecological survival." The lack of a critical and ethical critique in technology education is consistent with a utilitarian conception of technology that finds such questions largely irrelevant to the more potent issue of economic competitiveness. I am suggesting that a more authentic view of technology for the informed citizen of 1990's is one that includes a recognition that the logic of technological problem-solving is not sufficient (Franklin, 1990), and its use in the absence of an ethical or environmental imperative is responsible for much of our present ecological and social problems, rather than being a panacea for their solution.

Certainly when one comes to the learner expectations for science, technology and society, the situation looks more promising. Here, the student is encouraged to develop "an appreciation of different perspectives that bear on societal decision-making (e.g., scientific, technological, personal, social, environmental)" and to "compare and evaluate the consequences of each alternative" in decision-making. But this is only in the context of personal and societal decision-making, not as an integral part of technological problem-solving. It seems that the engineer or business person is to develop products or processes free of ethical judgment, and to let society make the decision, implying that technological production is value-neutral and that the responsibility for such deliberation does not lie with the technologists themselves.

The program authors do suggest that "developments in science and technology often significantly impact on society," that "societal needs and concerns often stimulate or influence technological problem-solving," and that "many of the effects of science and technology on society are unforeseen" (p.5). None of this, however, explicitly suggests that the impacts, concerns, or effects might be negative, as well as positive. In trying to be politically neutral, and omitting a critical stance or a moral commitment, the authors have put forward a sanitized picture of technology in society, at a time when our very survival may depend on the ability of all decision-makers to ask the right kind of questions about technology; questions that ask: what are the negative consequences of this technology for individuals, minorities, society, the biosphere?", and "should we be doing this?", to weigh against questions of efficiency, economic benefits, jobs, and profits.

How authentic a view of science and technology, then, does Alberta junior high science depict? The preceding discussion makes the case that the image of science and technology portrayed is mostly adequate and accurate, as far as it goes. One must

admit that there are limits to the complexity and sophistication of an account of science appropriate to heterogeneous groups of 12-15 year olds. Nevertheless, the program perpetuates a somewhat oversimplified and standardized view of science, that fails to capture the modern image of science as a complex, subjective, value-laden and pluralistic human endeavor (Hacking, 1983). Likewise, the depiction of technology, while a good first effort to introduce technology to young Albertans, fails to draw attention to the "real world of technology" (Franklin, 1990), or to equip our youth with the ethical perspective on technology so necessary for our uncertain future. What we find is a view that leans towards academic and utilitarian conceptions which have in common an instrumental outlook on science and technology.

The Learner and Learning

A Constructivist Approach to Learning

Prior to the curriculum change, despite references to "understanding" and "concept formation," the Alberta Junior High Science Curriculum Guide (Alberta Education, 1978) made no commitments to any particular model of learning. The 1990 program, on the other hand, makes extensive use of the language and ideas of constructivist psychology. The constructivist view of learning, primarily derived from the work of Jean Piaget and his followers, maintains that learners actively construct meanings from their individual experiences of the world (Driver, 1988; Millar & Driver, 1987; Osborne & Freyberg, 1985; von Glaserfeld, 1991). Knowledge, in this theory of learning, is not passively received by the learner, but is actively built up and serves the adaptive function of organizing experience in a coherent fashion. Pupils' knowledge and understanding of their world, according to constructivism, can only be individual subjective constructs, or workable frameworks of concepts, but never the discovery of an objective reality that is "out there". In constructivism, we see a number

of assumptions which are quite at odds with the positivist perspective, but much in harmony with post-positivist thinking.

The rationale and philosophy section of the curriculum document contains a number of indicators of the authors' psychological orientation. Concepts are to be introduced "through a broad range of experiences... (and)...in keeping with the developmental level of the students....students are given opportunities to reflect on their experiences, learning to discover and construct meaning through careful and focused thought" (Alberta Education, 1990, p.1). Evidently, the developers have been influenced here by Piaget's theory of developmental stages (Furth, 1970), and have concluded that learners at the junior high school level (roughly ages 12-15) need concrete experiences in order to form concepts. The language of the introduction is suggestive of a certain amount of constructivist influence. The emphasis seems to be on experience ("providing students with learning experiences"), understanding and meaning ("help students understand and interpret the world in which they live", "allow students to construct new meaning") and reflection ("students are given opportunities to reflect on their experiences", "students are involved in ways that will stimulate their critical and creative thinking skills"). Such discourse about learning could be interpreted as at least symbolic validation of a pedagogical orientation by Alberta Education for junior high science.

Images of the Learner

Early in the curriculum guide, a quotation from the policy document, Secondary Education in Alberta, states that aim of education is to develop individuals who will be "self-confident, capable and committed to setting goals, making informed choices, and acting in ways that will improve their own lives and the life of the community" (p.1). The image of the learner here is an autonomous, independent individual who can

participate fully in society, although it is not clear whether this is a picture of a secondary student here and now, or of a student projected into his or her future as an adult.

Interestingly, what is absent in the program of studies is any reference to the marketplace, employment, global competitiveness, or the need for scientifically literate and technically skilled workers, in other words, any explicit utilitarian justification for school science. Future employment for students and economic success for society are major concerns of parents, business people, politicians and others, and have been significant issues in debates over the senior high science curriculum in Alberta. The apparently benign public attitude towards the junior high curriculum has likely affected the development of the junior high science program and its success in the classroom, as discussed later. This means that, at least for the rationale and rhetoric of the program, more attention was focused on students, and less on the needs of the economy and universities, as shown by the aims for science education articulated in the document. It lists the primary aim as "providing learning experiences that help students understand and interpret the world in which they live," while the second and third aims are application of science/ technology knowledge and skills, and preparation "to support further study of the sciences." It seems that the highest priority being advanced in the program's setting out of its commitments is the student's need to understand the world they live in, a personal, here-and-now kind of learning. Yet we have seen earlier that the placing of students' intellectual development ahead of utilitarian knowledge for life and work and academic preparation is somewhat at odds with the form of the curriculum.

The Teacher

The Place of the Teacher in the Production Model

What is the role of the teacher in the Alberta Junior High Science Program? On this, the authors are strangely mute. In fact, there are no references at all to teachers or teaching in its entire twenty-one pages. Is this an oversight, or the logic of a particular view of curriculum at work? The absence of the teacher in the program of studies, and its concentration upon "educational outcomes" is highly consistent with the *production metaphor*, which largely governs curriculum theory in North America (Kliebard, 1975). A central premise of the production model, which has its origins in the efficiency movement in industry, is the predetermination of ends. A sharp distinction is made between the ends of production—the products—and the means employed to achieve those ends. The criterion for the means selected is entirely instrumental efficiency. It follows from this orientation to education that the focus of a curriculum proposal should be the blueprints for the standardized product—desired student behaviors—with exact details of the process involved best left to the on-site educational managers and engineers. This, I would propose, is the thinking behind a program of studies consisting of one and a half pages of educational rhetoric followed by fourteen pages of "learner expectations" couched in behavioral terms.

But what is wrong with this approach? Surely exactness in specifying what students are to learn can only benefit everyone involved, providing confidence to students, parents, and administrators that the "right stuff" and sufficient of it has been learned, while acknowledging teachers' professional ability to select the most effective means at their disposal. Curriculum writers as far back as John Dewey have pointed out the flaws in this view, however. Dewey incisively waged philosophical war on the separation of ends and means as part of a general campaign against dualisms. Ends and

means, for Dewey (1964, 1966), are continuous and reciprocal, so that ends must be defined and evaluated in terms of the means for their attainment, or otherwise be empty and worthless. It is a fallacy, he asserts, to assume that a means chosen to accomplish a predetermined end will necessarily bring about that desired end, and not have other, possibly undesirable, consequences. Furthermore, Dewey would argue, ends cannot realistically be fixed from outside, but must emerge from the local situation and be founded on pupils' capacities, needs, and purposes, on local conditions, social demands, and the requirements of the situation itself. To this argument, Kliebard (1975) adds that the production metaphor applied to curriculum dehumanizes education and tends to stifle curiosity and genuine intellectual activity in schools.

In the case of a junior high science course such as Alberta's, it is erroneous to assume that desired concepts, skills and attitudes can be dealt with in isolation from the teaching and learning activities which give rise to them. Firstly, despite language such as "students will develop the following science inquiry skills," or "students will be expected to recognize," there is no reason, from what is known about learning, to expect that these precise outcomes are what will develop from a particular activity. Constructivist psychology, according to Glaserfeld (1991), argues that there is an indeterminacy associated with what a pupil will learn from a given experience, and consequently other concepts, behaviors, and attitudes besides the expected—both desirable and undesirable—are likely to arise. Also, there is no guarantee that the expected learner behaviors will be generated at all. Learning is highly situational, such that the logic of learning is contained in the situation itself, rather than in the simple linear cause and effect implied by the program of studies: planned behavior -> planned activity -> desired behavior. Accordingly, the ends to be served by a particular learning experience are best determined by teachers based on their personal knowledge of

students' purposes, interests and abilities, the materials and resources available, progress made during previous learning activities, and other situational conditions, rather than on prespecified ends determined elsewhere. From the practical, pedagogical, and philosophical viewpoints, ends and means should be co-determined.

Implications of the Program for the Teacher's Role

All the same, it is possible to infer the nature of the teacher's role implied by the program authors. The constructivist emphasis on "providing learning experiences that help students understand and interpret the world in which they live " (p.1), firstly requires that the teacher be preoccupied more with what is going on in her or his pupils' minds than with overt behaviors. To promote the development of students' conceptual understanding, the teacher must have a satisfactory notion of individuals' conceptual structures. Moreover, she must be concerned not so much with correcting "wrong answers," as with exploring and understanding students' thinking, with a view to adapting instructional activities to provide for conceptual change (Glaserfeld,1991). Secondly , the role for the teacher in generating understanding will be that of facilitator or guide. Constructivism calls for the teacher to select, plan, organize, and monitor learning experiences to furnish opportunities for students to construct their own meanings. The teacher's attention must be focused on selecting those learning experiences which are most appropriate to students' present understandings, capacities, and interests, as opposed to following externally imposed learning objectives. Thirdly, the teacher in the constructivist scheme will understand that conceptual structures cannot be simply transferred from teacher to student by communication, and that language use and interaction are central to conceptual development. Therefore, the teacher's role includes the promotion of interaction by students through discussion and group learning.

In addition, from the constructivist perspective, a distinction must be made between teaching-learning activities which aim at skill acquisition, and those that aim at facilitating understanding (Glaserfeld, 1991). The Alberta junior high science teacher's role will therefore involve structuring activities which promote learning concepts in a context of science inquiry skills, technological problem-solving skills, and decision-making skills. The science teacher will have to spend considerable time planning, organizing, supervising, and evaluating a wide variety of "hands-on" scientific investigations, problem-solving activities with various materials, products and structures, and group decision-making activities on societal issues. For the full range of concepts and skills identified in the program of studies to be developed in these activities, the teacher must allow for considerable student input and responsibility, as well as for open-endedness and ambiguity. All in all, in promoting conceptual understanding alongside skill development, the constructivist teacher's role is far removed from the traditional didactic transfer of knowledge to passive pupils. The experience or situation, rather than the teacher, becomes the ultimate source of knowledge. Guiding students through experiences and promoting interaction and reflection, rather than direct instruction, become the teacher's main activities.

Implications of the Program for Teachers' Knowledge

To this point I have been concerned with the meaning of the junior high program in terms of the science teacher's function. I will now pass to a consideration of its implications for teachers' knowledge and attitudes. To begin with, a constructivist role demands that science teachers have not only a thorough grasp of the premises of constructivist learning, but also a positive attitude towards it. Only then can they fully embrace what is required of them. Teachers must have at their disposal a large repertoire of teaching strategies, plus an understanding of their purpose in

promoting conceptual understanding, interaction, or skill development. At the same time, they must be comfortable with the greater uncertainty, open-endedness, and ambiguity implied by a constructivist orientation to teaching and learning.

To be effective, teachers should be familiar with and accepting of the aims of the program, especially with respect to its emphasis on conceptual understanding, application of science and technology, and scientific literacy. In the context of those aims, teachers in the junior high program will possess a good knowledge and understanding of science concepts and principles from the biological, physical and earth sciences, not to mention the nature of science and technology, and science-related social issues. In other words, much greater demands in terms of knowledge, attitudes and skills are placed on teachers by this program than was previously the case.

To sum up, I have tried to identify and clarify the way in which the Alberta Junior High Science Program conceptualizes the teacher. It should be clear from this account that there is a basic contradiction between espousing constructivist notions of learning on one hand, and listing page after page of detailed mandatory learning objectives on the other. The production metaphor (learning objectives) and the travel metaphor (teacher as guide) are simply not compatible. We see that there is a fundamental contradiction between the relatively autonomous constructivist facilitator called forth by the program's stated rationale and philosophy, and the teacher-technician faithfully producing prespecified behaviors from students demanded by the bulk of the document, and by extant top-down implementation strategies.

The Social Context of A Science Curriculum

The International Scene

It now remains to examine how the larger society might have given shape to the program of studies by examining the political, economic and social context of the

curriculum. In order to discuss the shaping of the Alberta curriculum, it is first necessary to consider the larger international context of STS curriculum in which it is embedded. Previously, three curriculum orientations were discussed—pedagogic, utilitarian, and academic (Goodson, 1983)—which provide a basic analytic framework with which to deal with STS curriculum diversity were examined. These orientations can also be seen as the embodiment of the various demands society makes on schooling. In the formation of STS curricula internationally, personal, social, political-economic, and academic demands stand in competition with each other, and are resolved in the substance of the courses developed (Fensham, 1991).

The academic tradition of curriculum was embodied in the last generation of science curriculum reforms, the "structure-of-the-disciplines" projects such as Nuffield Sciences, PSSC physics, CHEM Study, and BSCS biology, courses which dominated science curriculum in many parts of the world during the 1960's and 1970's. These science curricula were legitimated by university scientists with an interest in maintaining their subject (Fensham, 1991), and sought to provide future scientists and engineers with the concepts, principles, modes of thought and inquiry of particular science disciplines.

As the STS curriculum movement has gained momentum around the globe, and societal demands of school science have increased in both diversity and intensity, the pre-eminence of the academic orientation to science has been challenged by its rivals. There are some new STS courses which take a liberal-studies approach emphasizing the history and philosophy of science (Solomon, 1991), and appear to be academic in origins and orientation. Other STS courses are interdisciplinary and focus particularly on topical science-related issues, decision-making, and developing a scientifically literate citizenry. This group of courses reflects the personal and social demands on

science education, and appears to be primarily pedagogic in perspective, since pupils are the focus, whether as present individuals with immediate needs, or as future citizens.

Still other STS courses could be described as primarily utilitarian, since they perceive science and technology education as a means of wealth-production (Solomon, 1991) and reflect political-economic demands on science education. Although the science-technology-society curriculum movement presently embraces all three curriculum orientations, the utilitarian strand of curriculum thought seems to be predominant. Fensham (1991) concludes that, on balance, the secondary science curriculum of the 1980's, both STS and non-STS, has been fashioned to serve the interests of political, economic, and academic demands—the utilitarian and academic visions of education—to the virtual exclusion of other demands. He speaks of the "uncritical stance about science in society in the 1980's" (p. 3) in science curriculum, especially a lack of perspective on the environmental crisis, and the role of science and technology in it. Considering the state of the environment and the level of international concern about the environment and related social issues, the failure of science curriculum to address this concern is disturbing, and revealing. It is disturbing, because despite the severity and complexity of environmental problems, they are outweighed in the STS curriculum debate by political-economic considerations. That such an agenda has dominated science education internationally, is strongly suggestive of which interests hold the balance of power in curriculum deliberations.

The American Curriculum Debate

In the United States over the past decade, several authors have helped us to understand the nature of the struggle to define the curriculum and the larger purposes of schooling (Apple, 1982, 1986, 1990; Aronowitz & Giroux, 1985; Giroux, 1981,

1983; Perrone, 1991). American education has come under increasing pressure from what Aronowitz and Giroux (1985) term the "neoconservative agenda," now the dominant ideology in that country. Spurred by a growing domestic and global economic crisis, a conservative government-business partnership has turned to schools as both part of the problem and part of the solution for U.S. economic woes. From a historical perspective, this is nothing new. Perrone (1991) reminds us that the kind of school reforms called for—competitiveness, standardization, uniformity, a return to basics—"tend to coincide historically (1870's, 1930's, 1970's) with periods of economic insecurity and a decline in public confidence about the future" (p. 124).

What frames the neoconservative vision of education is economic rationality, that is, technical rationality applied to the economic sphere (Aronowitz & Giroux, 1985). A major implication of this orientation is an instrumental view of curriculum, in which knowledge is chiefly valued for its contribution to economic growth. The vision itself consists simply of economic success, while the major theme of conservative America's educational initiatives is "competitiveness." Peronne (1991) remarks, "we are called increasingly in schools to see the world through a lens of economic competitiveness, the latest public imperative" (p. 3).

Economic rationality generates the key slogans of the neoconservative educational campaign: public accountability and goal orientation (more testing), achievement and excellence (high test scores, rigorous math and science), standardization (greater control over students, the curriculum, and teachers) and school-business partnerships (Aronowitz & Giroux, 1985; Peronne, 1991). These proposals are mainly technical in nature, and evoke the positivist roots of economic rationality, with a predilection for the "scientific" approach to managing schools and its interest in prediction and control (accountability and standardization), its insistence on quantitative

data (testing), a reductionist conception of knowledge (behavioral objectives), and a belief in absolutes (standards).

The critics of the utilitarian conservative vision for education invoke alternative visions of social justice, freedom, participatory democracy, and the growth of young people, as opposed to economic success. As Aronowitz and Giroux (1985) write, "the new education debate has little to do with fulfilling the American dream of social equality" (p. 3). They argue that the right-wing agenda neglects the pressing social problems of the U.S.A. in the late twentieth century. In fact, Apple (1982, 1986, 1990) accuses the conservative coalition of seeking reforms that would tend to reinforce, rather than reduce the role of schools in reproducing a stratified social order and unequal power relationships. Moreover, like Dewey (1966) before them, Aronowitz and Giroux assert that the major function of schools is to prepare students for active citizenship in a democratic society, rather than for participation in the industrial workplace.

The neoconservative assumption of a simple linear cause-and-effect relationship between schools and economic performance has also been challenged. The conservative argument suggests that "progressive" educational reforms of the 1960's and 1970's resulted in loss of control over the curriculum, teachers and students, and in lower student achievement, directly resulting in poor economic results (Aronowitz & Giroux, 1985). Aronowitz and Giroux suggest that this argument is simply wrong in failing to recognize the real problems and the importance of factors such as international competition, a shift in the economy from reliance on agriculture and traditional manufacturing to high technology, poor planning, and so forth. Similarly, it overestimates the role that schools might play in any U.S. economic resurrection, thus advocating the wrong solutions to the wrong problems. This not to say that schools

and the curriculum play no role in creating wealth, but only to undermine a simplistic linear input-output model of schools and the economy which fails to address deep-rooted problems in government and the economic sector (Apple, 1986).

From a pedagogical point of view, Perrone (1991) argues that the ideology of economic competitiveness "takes too much away from the students themselves, the immediacy of their needs and interests," that it "looks beyond students...as if they weren't there" (p. 3). He stresses that this instrumental view of schools is too narrow, shortsighted, and parochial for the sake of both students and society, that a proper starting point for schools should be our young people, not the economic crisis. Furthermore, Perrone points out inherent contradictions between an ethic of competitiveness in schools and the need in a participatory democracy for cooperation and civic responsibility, and between increased testing and providing a challenging and positive learning environment within the nation's schools.

Critics also deplore the conservative right's attempts to structure and control teacher's work. Apple (1982, 1986) maintains that the introduction into schools of technical control procedures, such as prepackaged "teacher-proof" curricula and repeated testing, is deskilling teachers, turning them from relatively autonomous professionals into mere technicians or state functionaries. Deskilling consists of taking a job requiring considerable knowledge, skill and decision-making, and reducing it to a set of prespecified actions and results, requiring less skill and training. (Apple, 1982). Technical control through deskilling is accompanied by separation of planning from action, so that teachers merely execute plans set by curriculum developers elsewhere, with the content, strategies, pace, exact results, and as much else as possible already specified (Apple, 1982, 1986).

Other significant participants adding their voices to the conservative critique of US education have been the liberal humanists (Giroux, 1988), representing one particular strand of the academic tradition. The liberal tradition in education advocates a "great books" curriculum designed to initiate students into the best traditions of western thought. While acknowledging the value of the liberal arts, Giroux argues that in treating western thought and literature devoid of any historical, personal or social context, it uses high status knowledge instrumentally to limit access to professions and produce more discipline specialists, rather than to revitalize public life in a democracy.

The Curriculum Debate in Alberta

In Alberta, as elsewhere in North America, conflicting ideologies are contesting the shape of the school curriculum. As an illustration, the policy document Vision for the Nineties: A Plan of Action (Alberta Education, 1991) illuminates the present provincial government's position. This plan lays out the Minister of Education's priorities for Alberta schools over the ensuing decade, priorities very similar to the agenda of the U.S. neoconservative-business partnership in the 1980's. The underlying motive for improving science education, a key component of the vision, is that "more students pursue careers in science; ...this improves Alberta's competitiveness in the world economy" (p. 21). The vision "focuses on goals, results, and accountability" (p. 2), and "dynamic partnerships with business and other community groups" (p.5). "Excellence in education" is the goal, which means, "our students will be at the top in national and international test results....and we will make significant improvements on diploma and achievement results" (p. 4). "Ongoing improvements to the efficiency and effectiveness of the school system" (p. 8) will also play a role in accountability.

These selections illustrate that the values behind the Alberta government's vision are the instrumental values of the "conservative restoration" elsewhere in the English-speaking world, that conceive the main role of schooling as the provision of a well-educated labor force to fuel economic growth. It seems that the Minister of Education has imported the U.S. neoconservative platform of the 1980's wholesale (e.g., The National Commission on Excellence in Education, 1983), complete with the requisite assumptions, beliefs, rationality and slogans. Economic success and competitiveness are what constitute the narrow vision of the government-business partnership, with the students themselves virtually ignored, other than as a means to an end.

Other interests embroiled in the Alberta curriculum controversy, and with the science curriculum in particular, include the academic interest and the pedagogic interest. The academic voice, represented by university subject matter specialists, especially those in the science disciplines, have had a significant impact on the discussion, notably through their influence as subject matter experts and their role as academic gatekeepers to post-secondary education. Not surprisingly, science professors tend to argue for a solid foundation in the theoretical knowledge, facts, principles and skills needed to equip students for the rigors of university science courses, and predict dire consequences if this body of knowledge is not transmitted practically in its entirety.

For instance, in their response to a proposal for an STS-oriented high school science program, the University of Alberta Faculty of Science (1989) described the STS content of technology and social issues as "social science masquerading as science" (p.2), and concluded that "we are concerned with the 'watering down' of science in the school system. This dilution will result in a generation of individuals

who will be deficient in basic knowledge and skills" (p. 4). The university scientists feel that the mandate of the secondary schools is to "adequately prepare students for post-secondary programs dependent on science" (p. 4), and that "science curriculum development should be primarily the responsibility of professional scientists and teachers educated and trained in science"(p.3).

The other major stakeholders contesting the science curriculum in Alberta are those teacher representatives, university educators, curriculum specialists, parents, and others who advocate a curriculum that has students at its center, rather than its periphery. Arguments from this perspective have revolved around student learning characteristics, needs and interests, and the involvement of all students. As one example, the Alberta Teachers' Association Science Council's (1991) primary criterion for curriculum policy is that "the students' interests should be foremost in our minds" (p.2), while other criteria include "broad enough to encompass students of K-12 and students of high to low ability and aptitude in science", "future-oriented", "positive", and "forward looking." And unlike the university scientists, the representatives of Alberta's science teachers are in favor of "expanding the goals of science education ; i.e., the skills, attitudes and STS concepts components of the curriculum" (p.4). The ATA document also offers some insight into the changing balance of power of interest groups in the province: "Alberta Education has broadened its base of input and teachers (are) no longer the primary source of feedback on curriculum matters. Other interest groups in total seem(ed) to have more influence than teachers on the decisions being made" (p. 1).

As I have tried to show, the general form of the curriculum debate in Alberta is very similar to that described in the literature for the U.K and U.S. Different interest groups with conflicting intentions, visions, and demands are contesting the question,

"what counts as science knowledge?" Broadly speaking, as these are by no means mutually exclusive categories, there is the academic perspective, represented by university scientists, the utilitarian "economic competitiveness" perspective, voiced mainly by government and business, and the pedagogic point of view, promoted by teachers, university educators and others. As the senior high science course was battled over for several years by these groups, it sometimes would move towards a utilitarian vision, sometimes towards a more academic one, and finally to its present condition representing a compromise between the three major interest groups tilting somewhat towards the academic and utilitarian conceptions of science curriculum, as suggested by the ATA Science Council.

Given this social and political context at the international, continental, and local levels, where is the Alberta junior high science program? Firstly, it appears that the junior science course has not been as controversial its senior high equivalent, although the planning and introduction occurred over the same time period. Neither the academic university interest or the government-business economic interest seems to have played a key role in its formation. Instead, curriculum specialists and Alberta junior high science teachers were the major players in the development of the program. One can conclude that from a post-secondary and economic viewpoint, the junior high level in Alberta was not considered crucial to future success, and attention was directed elsewhere. What counted was senior high, the last best chance for preparation for university education or the hi-tech workplace, leaving the junior high curriculum irrelevant to the debate.

This situation has allowed space for the development of a program which seems to be basically pedagogic in its orientation, albeit filtered through a technical lens. Herein lies its fundamental contradiction. While the program's overt message is

constructivism and science for the active informed citizen, its form, as lengthy lists of separate learner behaviors, speaks of technical rationality, control, and an instrumental view of science curriculum. Which face of the program is recognized will depend on the inclinations of its readers.

Conclusion

I have tried to demonstrate that the Alberta Junior High School Science Program, like science-technology-society curricula in general, is a hybrid, born of differing conceptions of science curriculum. It is a compromise, if not a consensus, between differing demands on the science curriculum, representing a variety of views on the purpose and nature of schooling. This compromise gives the written curriculum a schizophrenic appearance. We find the rationale and philosophy, the face of public legitimation, proclaiming that what counts is students' self-constructed meanings and understandings of their world, with utilitarian application of knowledge, and preparation for an academic future of lesser importance, while the specific content speaks a different story. The form of most of the program of studies, as long lists of behavioral expectations, reveals the hand of technical rationality in government policy attempting to precisely control what is taught and learned, despite rhetoric about constructivism and independent autonomous students. It was argued that the portrayal of science and technology given is basically sound, but tends to present science and technology in an oversimplified and instrumentalist way, and fails to sensitize students to the negative as well as positive effects of science and technology, or to the ethical dilemmas raised. This is not to say that the program has no merit; on the contrary, it represents a considerable advance over the previous discipline-based program.

The results of the analysis also clarify the way in which competing ideologies might shape science curricula under different circumstances. Although the Alberta

Junior High course avoided the vigorous debate which has greeted other STS courses, it bears the unmistakable stamp of academic, utilitarian, and pedagogic influences. The mixed messages given by the program suggest how the interests of different groups are resolved at the political and practical levels. At the more basic level of underlying philosophies, I contend that what we are looking at is the rubbing of positivism and its manifestations against a growing body of postpositivist thought, as the implications of modern science, philosophy of science, social, political, and environmental problems are reflected upon around the world, and people increasingly focus on ethical concerns about what is right for individuals, society, and the biosphere.

This analysis suggests the necessity for STS curriculum investigators to recognize the diversity of intent and meaning in different approaches to science-technology -society education—to acknowledge the contradictory underpinning assumptions and values, and to ask which interests are being served. The descriptive and uncritical approach seen in much STS literature underrates the importance of an ideological struggle the outcome of which may strongly affect our collective futures. It also implies a need in the present study for alertness to the presence of different conceptions of curriculum and competing philosophical assumptions, as well as for a recognition of contradictions in intent and meaning inherent in the program and in the teachers' experiences and perceptions. Sensitivity to and reflection upon these issues is essential for the kind of understanding of STS education and its role that we must have to ensure a future for our young people and their earth.

CHAPTER 4

Research Methods

Introduction

In any inquiry, there is a dynamic interconnection between the methods chosen, the questions being posed, and the researcher's underlying theoretical framework. In this investigation, an understanding is sought of the experiences of teachers as they encounter a curriculum innovation in their working lives. The question arises in the context of a particular set of postpositivist assumptions and beliefs about the world, and in light of a practical commitment to "pedagogy"—an orientation towards what is right for young people. All this points towards an interpretive study, a search for understanding of some aspect of human social life, such as, in this case, the interactions of teachers, students and novel subject matter in junior high classrooms. This chapter attempts to (a) sketch out the theoretical frame on which the study's methodology is built, (b) describe the nature of the methodology which arose from the interaction of question, theory and the research situation, (c) give a rationale for methodological decisions, and (d) provide an account of the measures taken to promote credibility and validity of the data and analysis.

Social Research Perspectives

Curriculum research is a branch of the larger sphere of social research—inquiry into human social life. For the last century or more, a central problem of social research has been which methods are most appropriate to its human subject matter (Lessnoff, 1988; Polkinghorne, 1983). What is at issue is whether the highly successful methods of the natural sciences can be legitimately applied to the study of social phenomena, or are other approaches more practically and philosophically suitable? In recent times, the answer has been increasingly in favor of alternatives to

the "scientific" genre of social research, as developments in science and the philosophy of science, and increasing concerns about its poverty of results and ethics have raised serious questions about social inquiry as "science."

A comprehensive theoretical tool for examining these alternative perspectives on social research is that of critical theorist Jürgen Habermas (1971). The central doctrine of his framework is that knowledge is always governed by one of three specific interests, namely technical control, understanding, or emancipation. These knowledge-constitutive interests in turn generate three distinct orientations to social inquiry: empirical (technical), interpretive, and critical.

The empirical orientation, with its philosophical roots in empiricism and positivism, embraces the view that natural science is the correct model for methods used in the study of humankind. Habermas argues that its knowledge-constitutive interest is the ability to predict and control nature: including humanity. This perspective implies positivist assumptions such as a world independent of the knower and describable by universal laws, value-free knowledge, linear causality of events, a "copy" theory of truth, facts only accessible through sensory experience—in sum, what Habermas refers to as the illusion of objectivity. It is a stance that attempts to emulate the "positive" success of the sciences in explaining, predicting, and controlling the events of nature.

The interpretive and emancipatory orientations share in a critique of social research based on a negative evaluation of its legitimacy for the study of human social life, and a refutation of its positivist philosophical assumptions. The growing body of interpretive inquiry, which embraces a variety of approaches such as phenomenology, hermeneutics, sociolinguistics, ethnography, and symbolic interactionism (Collins, 1992), has much of its intellectual roots in nineteenth century German social theory:

the *Geisteswissenschaften*, or "human sciences" (Erickson, 1986). Dilthey, a leading proponent of the human sciences, argued that human phenomena differ from natural phenomena in that human action calls for interpretation and understanding, whereas natural events involve external observation and explanation: "nature we explain; physic life we understand" (cited in Habermas, 1968, p.145). More recently, Oakeshott makes the distinction between "processes," events which occur in nature, and "practices," events that result from human decision and action (cited in Postman, 1988). Because the events of human social life are fundamentally different from the objects studied in the physical sciences—not determined by universal laws, but filled with meaning, and framed by human intelligence, free will and choice—physical science does not provide a legitimate model for social research.

The interpretive orientation to research is formulated upon a number of postpositivist assumptions, drawn from advances in science, philosophy, and psychology, that more or less constitute the counter-case to positivism (Lincoln & Guba, 1985). Interpretive research acknowledges multiple realities, socially constructed through language, and based on each individual's unique frame of reference. From this perspective, the knower and the world are inseparable and interact to influence one another, knowledge and inquiry are value-laden, universal laws are replaced by working hypotheses, and linear causality is replaced by the mutual simultaneous shaping of events (Lincoln & Guba, 1985).

Whereas the technical interest calls forth a technical kind of understanding of the world, based on producing knowledge in order to gain mastery over nature, the interpretive researcher's interest in understanding is of a different order. It is an interest, as Grundy puts it, "grounded in the fundamental need of the human species to live in and as part of the world" (1987, p.13), so that the interaction and

communication of human social life become major concerns. Rather than acting on an objectified world, here human interaction means communication between persons who see each other as subjects, who seek shared meanings. Living in a social environment in which fellow humans are conceived as subjects, instead of objects, and where free will and choice are possible, also means that understanding has an ethical dimension; it becomes a practical interest in discovering the "right action" for a particular set of social circumstances (Grundy, 1987; Smith, 1992). The interpretive researcher thus sees inquiry as having a clear moral purpose: to improve society by contributing to human understanding and decency (Postman, 1988; Smith 1992).

The critical or emancipatory orientation to inquiry can trace its roots back to nineteenth century thinkers such as Marx and Engels, but has come to the fore in the last few decades under the influence of European critical social theorists such as Habermas (1971), Marcuse (1968), and Gramsci (1971), and through the contributions of curriculum writers such as Apple (1990), Giroux (1983), and Freire (1989). The critical perspective shares many assumptions about reality and humankind's relation to the world with the interpretive view. However, critical theorists assert that understandings derived from a practical interest are insufficient, partial and one-sided (Lessnoff, 1988). An interpretive understanding of society is constrained by society's own understanding of itself, and thus misses features of social life such as taken-for-granted conventions, beliefs, and values, and unequal material and power relationships. Critical or neo-Marxist inquiry assumes that *only* critically reflective knowing will allow humanity to realize its fundamental interest in freedom and emancipation, through increasing self-awareness and erasing "false consciousness."

As a counterbalance to positivistic technical modes of inquiry, and in drawing attention to social-political issues, critical theory has been fruitful. Nonetheless, several

contradictions within the critical orientation have been noted, and a number of its fundamental assumptions have been questioned. Firstly, it has been argued that Habermas' notion of a "objective," "value-free" social science, with the end of emancipation, implies the seeking of appropriate means to that end, and places it in the realm of technical knowledge which critical theory denounces (Lessnoff, 1988). In a similar vein, Barrett (1979) suggests that critical theory, specifically Marxism, along with positivism is a product of the technical era, in that both share the will to explain, predict, and ultimately control human reality and destiny.

The critical orientation has also been critiqued by hermeneutic philosophers such as Gadamer. The main points of this argument have been voiced by Gadamer in the so-called "Habermas-Gadamer Debate" (Ricoeur, 1981). Gadamer's hermeneutics is carried out within a given culture and tradition, but nevertheless incorporates a critical perspective on that authority. Whereas Habermas asserts that only a critical consciousness will reveal the "frozen power relations" and "false consciousness" that are always present but often concealed within a tradition, Gadamer points out that the emancipatory critique itself is a tradition. Hence critical theory cannot escape from distorting its own cultural conditions. Furthermore, as the interpretive orientation itself contains a critical perspective, hermeneutic versus critical becomes a false dichotomy (Ricoeur, 1981). The status of the "emancipatory" cognitive interest as an inherent necessity of human life, as opposed to a social ideal or goal, seems highly questionable and difficult to demonstrate, unlike the technical or practical interests (Lessnoff, 1988).

Defining The Study

What remains as an appropriate epistemology and methodology for the study of human society in general, and specifically, the meaning for teachers of experiencing new subject matter in the classroom? Although some researchers (Lather, 1992) are

moving towards a fourth conceptualization of inquiry overlooked in Habermas' account (the post-modern), the interpretive mode of inquiry seems most harmonious with the question under investigation and the researcher's theoretical and ethical commitments. The research is about discovering shared meanings of social interaction between teachers and young people, and so poses the moral questions "what is the right action here?", and "what is the right subject matter for these pupils?" Such questions presuppose critical reflection upon the social circumstances surrounding those interactions and subject matter, in order to fully explore what is "right."

The study is theoretically anchored in the hermeneutic and phenomenological traditions within the interpretive framework. A phenomenological orientation means that I attend to describing teachers' lived *experience*, and try to return "to the things themselves." Acknowledging that both the participants and the researcher will be involved in *interpreting* lived experience comprises a hermeneutic stance (van Manen, 1990). Hermeneutics involves interpretation by people who confront concrete situations in which practical choices must be made, in light of beliefs and values handed down within a historical tradition, which includes a criticism of the tradition one draws upon to construct meaning (Elliot, 1987). van Manen (1990) argues that hermeneutic reflection on lived experience radicalizes thinking, making us more aware of taken-for-granted aspects of the lifeworld, although phenomenology does not prescribe any particular political agenda. Grumet (1988), on the other hand, advocates a dialectical phenomenology "that moves back and forth between the world as it appears to us and the world we refuse to see" (p. 65). She sees Husserl's "back to the things themselves" as an inadequate idealism fascinated by essences and subjectivity, but ignoring the conditions and relations of social life. Grumet's dialectic phenomenology recognizes the "interplay of freedom and facticity," of "our perceptions of the

phenomenological world" and the "philosophies, ideologies, and pedagogies of our culture" (p. 74). Certainly critical theory provides the insights necessary to ask many of the relevant questions about philosophies, ideologies and pedagogies, such as "whose interests are being served?" or "where does the power lie?". However these are only some of the right questions to ask, and simplistic self-fulfilling neo-marxist prophecies do not necessarily further a deep understanding of a highly complex and multifaceted human social life.

The discourse on interpretive research methodology reveals a somewhat confusing descriptive terminology, emphasizing different facets of research activity, and sometimes masking differing sets of assumptions about research. For example, much of the literature consulted on methodology, bears the name "qualitative," a name which really discloses little substantive information about the research, since it merely refers to an absence of quantification, a denial of some positivist conceptions, and the presence of some sort of "qualities." Likewise, "case study" is an unsatisfactory term indicating an empirical inquiry of limited scope: "an intensive holistic description and analysis of a single entity, phenomenon, or social unit" (Merriam, 1989). This, of course, says nothing of the theoretical orientation or intention of the research. A further distinction is made as to the "naturalistic case study," in which the researcher endeavors to reach a deeper understanding of participants' meanings in a natural setting (Lincoln & Guba, 1985). Insofar as this goes, then the present study could be described as a naturalistic case study, the unit of study consisting of a limited number of classrooms in which teachers and students are experiencing curriculum change in a "natural" setting.

Several curriculum writers have called for qualitative case studies as an appropriate method of inquiry into curriculum issues (Fullan, 1982; House, 1979; Stenhouse, 1982). More specifically, the case study has become an accepted mode of

research in science education (Easley, 1982; Rist, 1982; Roberts, 1982b; Smith, 1982). Although historically, science education research has been dominated by the positivist "product/process" model of inquiry, and still is to a large extent, more recently a growing number of science educators are recognizing interpretive studies as important and viable alternatives to "scientific methods." What is not so clear is what the purpose of the research should be: whether a better understanding of science classrooms to facilitate technical curriculum implementation strategies or higher achievement test scores, or an understanding with a moral purpose such as doing the right thing for students, working towards a just society, or conserving the biosphere.

Thus this study of science curriculum in the classroom, like other interpretive studies, defies short simple labelling, but could be more fully profiled as follows: (a) *basic data type*: qualitative, (b) *philosophical orientation*: interpretive (postpositivist), (c) *scope*: case study, (d) *setting*: naturalistic-school classroom, (e) *methodological commitments*: phenomenology, hermeneutics, (f) *moral commitments*: pedagogy, a just democratic society, environmentalism, (g) *subject matter*: junior high science-technology-society education. However, even the labored definition above does not capture the intention of the study. What is needed ultimately to grasp this is a metaphor. In essence, the method of the interpretive researcher is *storytelling*—creating a narrative about human social interaction (Postman, 1988). It is storytelling in that

an author has given a unique interpretation to a set of human events, that he has supported his interpretation with examples in various forms, and that his interpretation cannot be proved or disproved but draws its appeal from the power of its language, the depth of its explanations, the relevance of its examples, and the credibility of its theme (Postman, 1988, p.13)

And, like many kinds of stories, it involves putting forward metaphors, images and ideas with a moral intent, in the hope that its readers might reach a deeper understanding of some aspect of his or her world.

Getting Started: Gaining Access

In May 1990, while still engaged in doctoral coursework and proposal-writing, I made initial contact with school superintendents over the telephone and followed this up with personal meetings and a discussion of the research outline (see Appendix 1). Superintendents of both public and separate school boards were very accommodating and sympathetic to the study, and made no demands as far as paper-work was concerned, giving me a free hand to conduct my research, as long as I kept them informed of my intentions. I gathered that the small size of the school districts, as well as being their distance from universities and educational researchers, made for a more informal attitude towards researchers, and less bureaucratic "red tape" than is often the case in larger centres.

After talking to the superintendents, I then contacted principals for permission to have access to individual schools and teachers. As with the superintendents, the principals I spoke to were helpful and encouraging, which was very gratifying to this nervous researcher, whose academic career hung on the thin thread of their cooperation. The principals were able to identify the grade seven science teachers in their schools for me, and also ventured their opinions as to which teachers were likely to respond positively, and which were too inexperienced, likely to be too busy, and so on. I then telephoned the most likely prospects, and later discussed the project with them at their schools, before or after school, or at lunch break. The teachers were given the same research outline as superintendents and principals (Appendix 1), and

three teachers, two from the public system, and one from the separate system, tentatively agreed to participate in May 1990.

At the beginning of the 1990 school year, when I again contacted the three teachers, one confirmed her participation, but two others had been re-assigned to different schools or subjects. This would have placed the study in considerable jeopardy, but fortunately, another teacher, whom I had met during a summer course at the university, enthusiastically volunteered to take part in the study. During the proposal phase of the research, I had decided that for the chosen research question, theoretical framework, and methodology, a relatively small number of participants—from two to four—would be most appropriate. What was needed were larger amounts of data gathered over a fairly long time period, coupled with an increasing level of trust and familiarity with the participants, as opposed to smaller amounts of data from more participants and settings. The dilemma is *depth*—a deeper understanding of the experience of fewer teachers, against *breadth*—a more superficial understanding of more teachers' situations. As long as the metaphor for an interpretive study is human storytelling, and not scientific surveying with its attendant concerns of sample size and validity, resolving the dilemma towards the former seems reasonable.

In early September 1990, we discussed the basic thrust and orientation of the research, and the details of schedules and timing. Both teachers had afternoon classes accessible to the researcher, who had scheduled his full-time college teaching duties so as to leave afternoons free. The study was planned so that the bulk of observations, interviews, and document collection with each teacher would coincide with the teaching of the science-technology, and the science-technology-society units. These units were chosen for study as they seemed to be the subject matter in the grade seven work most characteristic of STS curriculum, and probably constituted the greatest departure for

teachers and students from a more traditional approach. Both would start teaching the science and technology unit in October, so I was able to begin preliminary data collection in early October.

Data Collection

Data collection in the study consisted of the standard methods of case study research in schools: classroom observation, conversational interviews, and document collection. The plan for data gathering was that it should be funnel-shaped (Erickson, 1986; Spradley, 1980): a wide angle view at the outset, while comprehensive descriptive observations of the setting and participants were made, becoming more focused and selective as the research questions and emergent themes became clearer. During data collection, despite careful planning, there lurked a constant uncertainty about the nature and amount of data being collected, whether I was on the right track, whether I was actually finding out anything at all—quite unlike my experiences of biological research with mink, lobsters, and parasitic worms. Erickson writes of interpretive research: "the central issue of method is to bring research questions and data collection into a consistent relationship, albeit an evolving one" (1986). My uncertainty was partly the result of the tension between deliberate planned design on one hand, and emergent design on the other. Preliminary decisions must be made, and the study must be disciplined by the question, but at the same time, the researcher must allow the design to evolve from his or her communicative interactions with the participants, from the developing situation, and from the continuing analysis and interpretation of data. The uncertainty I felt in studying human interactions in an interpretive way reflects the difference between the indeterminacy and ambiguity of human social life, and the lesser degree of each encountered in experimental studies of

organisms which, while still amazingly complex, have no language, psychic life, or personal meanings that we are aware of.

Classroom observations were done "free-form" (Smith, 1982), without checklists or predetermined forms. My field notes of classes, "the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data," were "detailed descriptions of people, events, activities, what is said, along with ideas, reflections, and emerging themes" (Bogdan & Biklen, 1982). Since the study borrows from hermeneutics and phenomenology, I tried to keep in mind van Manen's (1990) notion of "close observation," in which the researcher tries to enter the lifeworld of the participant, while at the same time "retaining a hermeneutical alertness to situations that allows us to constantly step back and reflect on the meaning of those situations" (p. 69).

Classroom observations, carried out over an eight-month period between early October and mid-May, were intended to not only validate participants' meanings, but also to establish a base of mutual experience for conversation. During the first week a whole school day was spent engaged in comprehensive observations in each school, followed by full afternoon observations for the rest of the week. In the subsequent weeks, three 45-minute classes per week were observed with each teacher as the two targeted units were being taught, the frequency of the visits diminishing as the study progressed, and a sense that little new information or insights were forthcoming. A total of about 20 classroom visits were made to each teacher's class. Since the classes were at different times in the afternoon, and the two schools are a five minute drive apart, observations could be made in both schools on the same day. Both Richard and Susan taught two different sections of grade seven science, one of which was followed

in each case over a four week period during the teaching of the "Structures and Design" and "Microorganisms and Food" units.

I had offered to be helpful to teachers by aiding in the classroom, working with groups, and taking classes (see Appendix 1), but it turned out that my participation was limited to teaching a few classes, and strolling around the room, talking to, and trying to help students as they worked individually or in groups. It seems I was closer to "observer as participant," than "participant as observer" in these classes, as I sat through many classes over an eight-month period, usually at the back or side of the room, watching, listening, talking to students, and trying to get the gist of it down in my notebook, with the intention of producing a text for recollection and reflection, as a common basis of experience, and as a validity check in conversations with the participants. According to my own observations and those of the teachers, I soon blended into the classroom, and was ignored by the teachers and most students (except a few with an apparent need for recognition from an outsider). The students' behavior, at least, seemed to be relatively unaffected by my presence. I had the feeling that students in both schools were quite used to visitors of various types.

The "conversational interview" is a conversational relation with a person about the meaning of lived experience, but disciplined by a research question (van Manen, 1990). In this case, the conversations focused on the meaning of lived experience of curriculum change, and had the practical intent of exploring what is "right" for young people (Carson, 1984; van Manen, 1990). Four one-hour or longer conversational interviews, guided by a series of topics or open-ended questions (see Appendix 2), were conducted with each participant over the eight-month period, and were audiotaped for later transcription and analysis. Both Richard and Susan, the two teachers taking part in the study, were very busy people, making it difficult in some cases to find

suitable times or places for uninterrupted conversations. Originally, a total of six to eight conversations with each teacher had been proposed for the study, but the final number of four was more realistic, and seems to have provided sufficient data.

Initial conversations with the teachers revolved around questions of background, relevant personal history, teaching and learning, and subject matter (e.g., questions #1-13, Appendix 2), while later conversations explored topics that arose from classroom observations, from previous sessions, or simply from the flow of two science educators conversing about students, teaching, and learning. The interviews varied from fairly structured to more conversational explorations of ideas and experiences, and were held in such varied locations as the teacher's classroom, a staffroom, a local restaurant, the participant's home, or the researcher's home. Before each interview, I prepared detailed notes summarizing the intent of the session, follow-up topics, or questions arising from previous conversations or classroom observations, as well as a transcript of the previous conversation for the teacher, along with whatever interpretations were available. After each conversation, I made fieldnotes to record initial feelings, impressions, reflections, and an overall evaluation of the session in terms of the purpose of the research. If it is understood that in interpretive research the researcher is the "instrument," the researcher's reactions (emotional or interpretive) are part of the record, as well as a check for biases, and a source of insights into the data (Smith, 1982).

Additionally, I talked with a district administrator and the principal of each school to obtain an overview of the district, its schools, their context, programs, demographics, and so on. Document collection at this stage concentrated on school materials that would give indications of the nature and climate of the school (brochures,

newsletters, and so on) as well as teacher-produced documents (lab handouts, tests, board notes).

Data Analysis and Interpretation

Interpretation as Hermeneutics

Hermeneutics is the philosophical theory of interpretation (Palmer, 1969). With its origins in biblical interpretation, philology, and law, hermeneutics was originally a way of interpreting the meanings of ancient texts for contemporary audiences. During the nineteenth century, Schleiermacher founded modern hermeneutic theory with a conceptualization of understanding that was grounded in grammatical interpretation, but moved towards a psychological interpretation, in which the task of the interpreter was to reconstruct the mental experiences of the writer of the text. Dilthey continued the project of hermeneutics which Schleiermacher had initiated. He was attempting to give subjective "human sciences" a basis of objective truth and validity to counter the claims to objective truth of the dominant natural sciences. Dilthey proposed that this basis of validity be achieved by focusing on historical understanding. Texts could be best understood in relation to lived experience, which is essentially historical in its context of meanings that reach both back into our past and forward to our future (Palmer, 1969).

In this century, Heidegger brought into question Schleiermacher and Dilthey's ideas of understanding. In asserting that all understanding is ontological—derived from *being* rather than thinking—he attempted to remove an epistemological dualism of scientific explanation versus historical understanding that had limited nineteenth century hermeneutics. Further, Heidegger contended that interpretation is linked to making explicit the pre-understandings embedded in language; for it is language which contains the essence of being. Heidegger's student Gadamer developed Heidegger's

phenomenological hermeneutics into a more comprehensive theory. Gadamer's hermeneutics retains Heidegger's emphasis on the centrality of being, history, and language to understanding, but suggests a dialectical relationship with text, an openness to being questioned as well as questioning the text, to both being told and telling (Gadamer, 1975). An essential part of this interplay for Gadamer was awareness of the prejudices and beliefs which are a function of the interpreter's particular tradition. It is with this kind of questioning of tradition, that a critical perspective becomes possible in hermeneutics.

I have tried to briefly trace the main lines of hermeneutic thought up to the work of Hans-Georg Gadamer, and to show the theoretical roots of the notions of interpretation and understanding inherent in the hermeneutic perspective, and its dialectic nature in relation to dialogue and mutual understanding. Data analysis and interpretation is, like all interpretation, a hermeneutic activity, so that the interpretive researcher should endeavor to maintain a "hermeneutic alertness" as he or she develops interpretations of human events.

Data Analysis and Interpretation Procedures

Of a number of different possible analytic frameworks, perhaps the most appropriate for hermeneutic-phenomenological study is *thematic analysis* (van Manen, 1990).

Making something of text or a lived experience by interpreting its meaning is more accurately a process of insightful invention, discovery, or disclosure—grasping and formulating a thematic understanding is not a rule-bound process but a free act of 'seeing' meaning (van Manen, 1990, p. 79).

Thematic analysis, according to van Manen, is "mining for meaning," trying to unearth something meaningful in the text, discovering themes that somehow make sense of experience, and capture its shape and essence. Smith (1982) suggests that the

researcher is attempting to develop themes that tie the elements of the case together, while telling a story through image and metaphor. We make sense of a mass of data by the creative and imaginative feat of discovering that "this phenomenon is like this other phenomenon": through an image, analogy, or metaphor which can be apprehended immediately and intuitively by the reader (Smith, 1982). In a critically-oriented phenomenology, the researcher also remains alert for the interplay of lived experience and context, of culture and ideology, for images and meanings beyond the confines of individual life, and to political and societal contexts (Grumet, 1988).

Data analysis in an interpretive study should occur both concurrently with and subsequent to data collection (Rist, 1982). Analysis begins with the very first observation or conversation, then emerging themes, insights and tentative hypotheses direct the subsequent phase of data gathering, which in turn may lead to redefining the question, and so forth (Merriam, 1989; Rist, 1982). Ongoing data analysis occurred in the study as I reflected and wrote about each classroom observation and conversational interview. Reflections and initial analytic comments were included within fieldnotes as asides, and as part of the reflective commentary for each observation or conversation.

Intensive analysis is the analysis of the data after concurrent data collection and analysis has been completed (Merriam, 1989). How could I make sense in an integrative way of this mass of data (hundreds of pages of field notes and interview transcripts, plus a limited amount of documents) even though some concurrent analysis had been accomplished as the study proceeded? I began by reviewing the proposal, to regain a perspective on the study's original questions and intended audience, and to assess how the data had changed or refined its focus. I then found a very large table, minimally organized the data (computer printouts and handwritten notes in bound notebooks), and proceeded to quickly skim through it in the Micawberish hope that

"something would turn up." What I was searching for were themes that addressed teachers' experience and thoughts of curriculum change. After much searching—and through a process more akin to intuition and creative imagination (van Manen, 1990), than to the inductive logic implicit in "grounded theory" methodology (Glaser and Strauss, 1967)—some themes began to suggest themselves. The teachers' own language in the conversation transcripts was most useful in providing the cues for development of themes. What seemed to be significant passages were color-coded, then I re-read each data source a number of times to test emergent themes against the whole data base. Similar themes were grouped together and subsumed to produce major themes. A conscious effort was made, as the themes were tested and re-tested against the data, to seek both confirming and disconfirming evidence (Erickson, 1986). I then proceeded to select data from different sources to produce descriptive passages about the setting and participants, to complement the analytic material, and hopefully strike a harmonious balance of description and analysis in the narrative. The intention in presenting data and its analysis and interpretation is to produce a manageable and credible account of participants' meanings.

Validity Issues

Are the interpretations produced by an interpretive study credible and trustworthy? Validity refers to the believability of one's findings: how well do they match up with reality? Are events and meanings depicted in the study as they really are? Because the interpretive orientation to research assumes that humans construct ever-changing multiple realities, it is not appropriate to assess validity by matching data and interpretations to a single fixed reality, to entertain a correspondence theory of truth, as might be the case for positivistically-inclined research. Instead, a judgement of validity for an interpretive study rests on different grounds.

Goetz and LeCompte (1984) describe four ways in which interpretive "field" studies can claim internal validity, or internal consistency: (a) long-term living and data collection with participants promotes a better match of researcher and participant perspectives and realities, (b) interviews must be conducted dialogically so that there is a common language and understanding, (c) observation is carried out in the participant's own environment, not an artificial setting, and (d) analysis incorporates a process of rigorous self-monitoring that constantly questions and evaluates data and interpretations. Lather (1986) suggests some methodological refinements to enhance validity in "openly ideological" studies to "protect our research and theory construction from our enthusiasms" and "guard against researcher biases distorting the logic of the evidence" (p. 67). Those relevant to this study include *triangulation* of not only methods, but also of sources and theories, the incorporation of a conscious search for counter-evidence, and criteria for excluding and including data. *Construct validity* requires the setting of theories against peoples' everyday experiences, with a systematic reflection which examines and modifies initial theoretical constructions in face of the evidence. In keeping with the notion of hermeneutic inquiry as intersubjective communication, Lather emphasizes *face validity*, or member checks. Such efforts to develop interpretations based on shared meanings involve going back to the participants with tentative results, so that the resulting interpretations are more consensual than one-sided.

A number of the above strategies were used in this study to promote validity. Triangulation was achieved through the use of multiple data collection methods: classroom observations and conversational interviews, and to much a lesser extent, document analysis, and through multiple sets of coherent theoretical assumptions. Triangulation of sources was unavoidably weak, however, given the restriction to two

participants. Relatively long-term association with the participants in their own environment, and their having similar backgrounds and outlooks to my own, probably contributed to a greater consistency of interpretation. In addition, I made a conscious effort to maintain a common language—to keep conversation, written data, and interpretations as accessible and "non-academic" as possible.

Throughout the study, face validity of data and interpretations by participants was sought by making raw data (transcriptions of conversations, researcher's descriptions of classroom events), interpretations, and analyses available to the participants for their reactions. In some cases the feedback was verbal, in the context of an interview, a casual classroom conversation, or telephone call, and in other cases (especially with Richard) the feedback was written. During analysis and interpretation, I undertook to be as self-reflexive as possible about my biases, prejudices, and feelings, and to document the extent to which initial questions and ideas were changed by the data. This is in keeping with the hermeneutic notion of a dialectical relationship with text, that entails a self-awareness of the prejudices and pre-suppositions associated with one's own tradition, and a questioning of the readers pre-understandings by the text. Due to constraints, I was unable to keep a daily reflective diary, recording such reflections in fieldnotes, on note-cards, or as asides in interpretations.

External validity, or generalizability, is the extent to which a study's findings are applicable to other situations or instances (Merriam, 1989). The interpretive study's findings are not generalizable in the traditional sense idealized in the natural sciences, which try to describe a uniform world with universal laws. In contrast to this, the results of an interpretive study have validity by virtue of the tentative nature of their inferences and the concreteness and richness of their detail. Findings are ultimately valid or generalizable to the extent that they "strike a resonant chord" with the reader,

that is, when they make sense, are consistent, when the reader can recognize similarities and applicability to their own situation and experiences (Lincoln & Guba, 1985; Merriam, 1989). In other words, when the reader has a sense, as with literature, myth, legend, and other forms of human storytelling, that a story "rings true" (Postman, 1988), this constitutes the most meaningful notion of validity for interpretive inquiry.

Ethical Considerations

Participation by teachers was entirely voluntary, and they were free to withdraw from the study at any time. Anonymity of participants and confidentiality of information is safeguarded by the use of pseudonyms for participants, students, schools and school boards, and the disguising of locations in the field notes and research reports. The data to be gathered, time commitments and so on were negotiated with participants. Interpretations of data—themes and detailed interpretation—were validated by the participants, and participants were free to add, modify or remove any information from the data gathered, or suggest alternative interpretations. Excerpts from the completed dissertation, and copies of published reports will be available to participants.

CHAPTER 5

Findings: Lived Experience of Curriculum Change

All of us have experienced many hours of classroom life, and many readers will have spent at least some of that time as a teacher. Yet relatively little seems to be written about the nature of classroom life, what that experience is like for those involved. We now turn to this question as we explore the lived experience of two junior high science teachers, Richard and Susan, introducing a new Science-Technology-Society course to their classes. After setting the context for the study with descriptions of the participant's, their schools and students, the chapter then deals with social dimensions of teachers' experience of curriculum change. Following this, we consider the existential themes of freedom and alienation as they relate to students' learning and Richard and Susan's daily teaching lives, and finally, participants' views on what it means to "implement" a curriculum.

Setting and Participants

The School District

The study was conducted in a small western city of about 30 000 people with an economy based on agriculture, fossil fuel recovery, and forestry. The two schools involved in the study belong to the city's public school district. An interview with the assistant superintendent revealed that the district contains ten schools: five elementary, two elementary-junior high, one junior high, and a single high school. In the 1990-1991 school year, 5 000 students were enrolled in the district, taught by around 300 teachers. The student population, which includes a full range of socioeconomic circumstances, is growing slowly, and unlike the large urban centres in the province, has experienced no significant influx of immigrant or ESL students.

The administrative structure of this small school district in relation to the "implementation" of a new junior high science curriculum, is relatively simple. It consists of a superintendent and two assistant superintendents (one responsible for human resources, the other for educational programs), but no subject area or other consultants. Instead, there are math/science coordinators at each of the three junior high schools, and a science department head in the high school. Alberta Education promotes the use of the "cascade model" for teacher inservice, which entails providing sessions for lead teachers (experienced volunteers) in each jurisdiction who in turn conduct inservices in their own schools, and sometimes in other schools. The cascade model of implementation, the assistant superintendent suggested, has been used with some degree of success considering the limited resources available, although Alberta Education is aware that it is not very effective. The ongoing implementation procedure for junior high science consists of regular meetings of the assistant superintendent with the math/science coordinators from each school, at which resources, text selection, and the success or otherwise of the program at their schools are discussed. The feedback received by administration on the new grade 7 science program thus far indicated that teachers were responding positively to the change. The teachers reportedly perceived an increase in student interest in science, and both teachers and students seemed to be pleased with the new program, and its greater emphasis on activities. The board had previously developed an activity-oriented elementary science program, and were pleased that there now seemed to be more continuity between elementary and junior high science.

The district administration's role in implementation, as they see it, is to facilitate the lead teachers' attendance of inservice sessions, and to facilitate implementation at the school level. In this particular case, the latter consisted of ensuring that personnel,

facilities and finances were available to enable the six teachers in the district involved in the new grade 7 science to "implement" the new program. It seems that, compared to larger jurisdictions, the teachers received relatively little support in introducing the new program, despite it being a considerable departure from their previous experience of science teaching. While one of the participants in the study, Susan had attended inservice sessions as a pilot teacher the previous year, Richard, the other participant, had received no inservice preparation since he returned from sabbatical after it had been offered.

Riverheights School

Riverheights School is a grade 7-9 junior high situated in a downtown location, with a student population of about 450 students from a wide variety of backgrounds and situations, from professional and blue collar to welfare recipients. Among this number are about fifty native students in all grades, some urban, and some recently moved from rural areas. About fifty students attend special classes such as a grade 7 learning disabled class, a grade 8 integrated occupational program, and a grade 9 modified curriculum program. The school has seven grade 7 classes, including five "regular" classes, one severely learning disabled group, and a French Immersion class. Among the five regular classes of up to about thirty students, there is no formal streaming, however, according to the principal, the organization of classes on the basis of options, or "complementary courses," constitutes a type of informal streaming. For instance, classes taking orchestra or band options are timetabled together, and these classes usually contain higher-achieving students. The situation for grades 8 and 9 is similar, in that each grade has a French immersion class, a "special" or modified curriculum class, and several regular classes.

The timetable at Riverheights consists of seven 47 minute "blocks," or periods, and while there are no formal home room blocks in the time table, there are "home room groups" who take four subjects together (math, science, language arts, and social studies), with usually the the same teacher for math/science and for language/social. The grade 7's then separate for their three optional subjects, which might include agriculture, art, band, choir, drama, French as a second language, orchestra, or outdoor education. Practical arts, a combination of industrial arts, home economics, and computers, is a locally developed "option" which is taken by all grade 7 students. Options for grades 8 and 9 are similar except industrial arts and home economics are taught separately, and business education is available for grade nines.

The professional staff at Riverheights includes twenty-seven teachers and three assistants. According to the principal's account, this is a stable, somewhat male-dominated staff with an average age of around thirty-five. They are an experienced group of teachers, with only two recently certified teachers, and all of the teachers have at least a B.Ed. degree, or a degree plus after-degree certification. Most teachers in the school are non-specialists, teaching two or more subjects, such as math/science/options or language arts/social studies. Specialist teachers include those teaching physical education/health, art, music, industrial arts, and home economics. The school's extracurricular program, described as "aggressive," includes a jazz band and an orchestra, as well as the usual volleyball and basketball teams. The physical plant of the school consists of a rapidly deteriorating thirty-year old building which does not provide sufficient classroom space for the present student population, and will soon need replacing. The building has two floors with the usual junior high school facilities: gymnasium, library, industrial arts shop, home economics room, art room, and two science labs.

The principal, a well dressed, articulate, low-key administrator, feels that student conduct at Riverheights is good for a junior high its size, and relates this to the "open climate." He maintains that the school does not have too many rules and regulations, and that discipline is based on "dignity and respect," rather than on rules and punishment. This was consistent with my experience of the school over an eight month period. It seems like a fairly positive environment, despite a small minority of students involved in "unacceptable behavior," violence, vandalism, drugs and so on. The school was also portrayed by the principal as a "high-tech school" on its way to becoming even more technologized in the future, with greater and more innovative instructional use of computers. Presently the school has a computer lab with Apple and Macintosh computers, a laser printer and a scanner, plus a Unix system which keeps track of student's records and performs other administrative chores. The principal sees his role in the implementation of the new junior high science program primarily in terms of providing the funds and facilities to allow the program to take place, with no direct role in curriculum implementation. The school science coordinator and the district assistant superintendent of curriculum have more direct involvement in the implementation process.

The grade 7 classroom where observations in this study were made was a large airy classroom with seven clusters of movable tables and chairs, three or four to a cluster. The different atmosphere generated by having students arranged in small groups, as compared to the usual straight rows, struck me right away. It also meant that I had to either join a group, which I did when there was a vacant seat, or take an isolated chair off to the side somewhere. A window ran the length of one side of the room, with a windowsill cum bench underneath used for aquaria, plants, displaying projects, and so forth, while underneath were shelves for textbooks. Along the other

side of the room were the fixtures proclaiming it a junior high science room: a long bench with sinks and an eyewash station, glass-fronted storage cupboards displaying the arcana of school science (glassware, chemicals, microscopes, pickled curiosities in large jars, scientific-looking pieces of equipment of unknown function, and models), and more well-stocked storage cupboards below. At the front was the rarely occupied teacher's desk, a filing cabinet, an overhead projector on a cart, and the inevitable blackboard and screen. Pasted on the walls, along with some animal posters, were large hand-printed exhortatory messages: "THINK: IS IT REASONABLE?"; "HE WHO EXPLAINS, LEARNS"; "SHOW RESPECT TO ALL," "USE QUIET VOICES," "EVERYONE CONTRIBUTES," "LEAVE YOUR PLACE CLEAN." The slogans are suggestive of Richard's approach to math and science teaching, as well as the cooperative ethic he tries to inculcate for the group learning which characterizes his math and science classes.

Richard

Richard is thirtyish, single, has wide-ranging interests, and spends many hours at his school, Riverheights, coaching and preparing classes. It seems that Richard is a "born teacher." Among administrators, colleagues and students, he has a marvellous reputation for his teaching abilities and the way he handles junior high students.

Richard describes how he became a teacher:

I've always been good at explaining things. Through junior high and high school I was the one hopping around the room explaining how to do things, and I always enjoyed doing it. My mother was a teacher and got so much satisfaction from it. It was something I always observed of her: "she enjoys the job." It was just something I drifted into—I didn't make a conscious decision. It did give me place to use my math without relying on it totally...I have no desire to be a mathematician.

Teaching was a way for Richard to carry on doing things that he really enjoyed: mathematics, explaining, and volleyball.

After receiving a university degree in math, Richard pursued a postgraduate education degree, majoring in math, with minors in French and physical science. It seems that, as for many teachers, math and science methods courses had little influence on his teaching—it was more a matter of "you teach the way you were taught." However, certain cooperating teachers on practice teaching rounds, whose methods and techniques Richard copied, did have a significant impact on his later teaching. Yet Richard does not conceive of teaching in terms of technique:

I try to be very much myself. If I see someone doing something I really like, I will copy it, but I have my own style, and I think that's valuable. I think teaching is a reflection of myself. As my own self-image gets stronger, I think my teaching becomes...an extension of me. I hear people talking about they're in "teaching mode," or "now I put on my teaching hat." I don't perceive teaching like that. It feels natural in the classroom—it doesn't feel like I'm staging anything in there, and at one time it did; it felt like I was going in there to perform.

This underlines one of Richards major teaching commitments: to authenticity. Teaching, he feels, must be a "reflection of self," not a separate persona, style, or tone, but a completely authentic act, such that interactions with students are more like other social interactions, with adults or friends. The commitment to authenticity also carries over to Richard's view of math and science curricula. Subject matter and learning should also be authentic for the kids as well as their teachers—real, concrete, personal, relevant, a reflection of their own selves, not just of the text, the teacher, or the curriculum guide.

Richard's thoughtful approach to teaching seems to have been nurtured by recent graduate studies in math education, which he pursued after teaching math and science at Riverheights for about five years. Although there had been a progression in his ideas about teaching, and he was never really happy with the old math and science courses, graduate coursework provided an understanding and appreciation of the

theoretical and philosophical underpinnings of the new constructivist paradigm in math and science curricula (a constructivist-influenced junior high math program had been introduced two years earlier). Richard's response to constructivism, in light of his junior high teaching experience is, "it seems obvious!" The change from representing math or science in terms of static facts to be memorized, to personal meaning, understanding, and relevance, to acknowledging Piaget's ideas about concrete learning, and towards a more authentic notion of learning, is one that Richard fully endorses.

Richard's perspective on his students' learning seems consistent with his views on education generally. He assumes that most junior high students need and want to learn, that they should be treated with humanity, dignity and respect, but at the same time need structure, routine, good work habits, and the motivation of marks. As he stands in front of the class, a neatly dressed young man of medium height and athletic build, he has an air of calm assurance. He talks fairly loudly to be heard in the large classroom, but rarely raises his voice, or loses his temper. As junior high school teachers go, Richard is fairly "laid-back." To me, he seems to have a fairly high tolerance for adolescent talk and behavior in class, a nice judgement on which distractions and misbehaviors to let pass, and which to act upon (a necessity for a boisterous and "difficult" junior high class engaged in cooperative group work).

The two grade 7 classes to whom Richard teaches math and science have about 25-30 students each. One class, 7Y, is a quiet, orderly, more academically-inclined group: "just a nice group of kids to work with," according to Richard, but "with a more bible-study like atmosphere" in class discussions. In contrast, the other class, 7X, is more boisterous, spontaneous but, on the whole, less academically-oriented and more difficult to manage ("we sort of get on each others' nerves"). This class has several "behaviorally complex" students who previously would have attended a special

class, but are now integrated into regular classes. Four of these students (who had difficulty working with others) form their own group next to Richard's desk, and one boy, "lost in his own little world," occupies a desk by himself on another side of the teacher's desk.

"Less academically oriented," as applied to 7X, means that although in oral discussions and practical activities they were energetic, thoughtful, and enthusiastic, when it came to written work, in planning and writing up labs, in assignments and in tests, they are less successful and less motivated, compared to Richard's other science class, 7Y. 7X is the class on which I concentrated my observations after the first week or so, mostly for the practical reason that my teaching assignment left afternoons free. But it is also the more interesting group to spend time with as an observer, and, as a very mixed group academically, possibly a better "acid test" for the STS concept of "science for all," and based on my experience, a more representative group of junior high students.

A typical school day for Richard begins at 7:00 in the morning with volleyball practice, or at 7:30 if there is no practice. He teaches six out of seven periods, including two math classes, two science classes, and agriculture and computer options. After some final preparations for the day, his teaching day begins at 8:30 with a math class with 7Y, followed by a science class with the same group, and then a prep period, Richard's relaxation, or "kick-back time," which nevertheless usually includes marking notebooks, tests, or assignments. The last period of the morning is math with the more demanding 7X group, followed by a 40-minute lunch break, including 10 minutes set aside for helping students with math or science problems, a quick lunch and chat with colleagues, and often a pick-up volleyball game with students and other staff. The afternoon brings another science class with 7X, then an agriculture class, and finally a

computer class. Before heading home, lies an hour or two of preparation for the next day, and on some days, more volleyball practice. It is easy to forget how busy and exhausting the everyday working life of a dedicated junior high teacher such as Richard is—with six periods a day of classes, up to two hours of volleyball a day, helping students, marking and preparation, time is a large element in Richard's teaching life.

Pleasant View School

Pleasant View school is a unique integrated school in a suburban area, with a regular kindergarten to grade 9 program enrolling about five hundred students, as well as special education programs for over one hundred children of a wide range of ages and abilities. The students in the regular program are mostly drawn from a newer neighborhood of single family dwellings and middle SES circumstances, but within that context, come from a wide variety of family structures. The principal is an experienced administrator probably in his early fifties, dressed conservatively in a dark suit, with a warm and pleasant manner, and a great deal of enthusiasm and pride in his school. According to his account, there are fewer and fewer students attending school with two natural parents at home. This breakdown of the traditional family structure he sees as a challenge to education, as children come to school with more problems, more basic needs not being met. The emphasis at Pleasant View school is on "caring and sharing." The principal feels that integration of regular and special needs students throughout different grade levels adds an extra dimension to the school, which prides itself on its happy and friendly atmosphere.

The junior high program at Pleasant View involves roughly 200 students in grades 7-9, including twenty physically challenged or cognitively delayed students integrated into regular classes (but none in the classes observed in the study). Each of the three junior high grades has two heterogeneously grouped classes. The first fifteen

minutes of each school day consists of a "home room" period which, besides the usual announcements, features 10 minutes of silent reading for all: students, teachers and staff. This is followed by the regular timetable of seven 45 minute periods. The junior high options include a fairly typical range of subjects for Alberta schools: agriculture, art, drama, choral and instrumental music, outdoor education and French. Extracurricular activities for the Pleasant View junior high program include team sports, as well a dancing club and science club.

The school has forty certified regular teachers, as well as eighteen specialists in such areas as speech, hearing, vision, physiotherapy, occupational therapy, and psychology. About ten teachers are involved in the junior high program, several of whom also teach elementary classes. The principal has recruited people for the junior high grades who are "flexible specialists," able to teach in two or more subject areas. It is a fairly young staff, over half male, with some experienced and some new teachers. But their primary qualification, says the principal, is a commitment to the "caring and sharing" vision of the school ; a belief that people and process are more important than content.

The school building itself is a unique and pleasing modern structure with an open and informal atmosphere, consisting of four wings spreading out from a central courtyard area with many plants and an attractive fountain. Two of the wings contain specialized facilities for handicapped students, including several swimming pools, rooms for therapy, consulting and so on. Another wing contains the gymnasium and elementary classrooms, and yet another houses the junior high facilities. The junior high facilities include a home economics room, an industrial arts area, two fully equipped science labs, as well as regular classrooms.

The grade 7 science room where Susan spends her teaching days is an interesting arrangement, combining a regular classroom with a lab area, plus an adjacent greenhouse and preparation room. The classroom has about thirty conventional desks in six rows, facing a blackboard and demonstration bench. The lab side of the room has a T-shaped lab-bench island, with stools. The lab benches do not seem to be currently used for lab work, being completely occupied by two large fish tanks, student projects on display, various boxes and miscellany. Around two sides of the five-sided room are benches with storage cupboards and shelves above. There are four cages with snakes of various kinds, and all sorts of other things on every available surface, including a large number of file boxes and cartons on the floor at the sides of the room. There are posters on the walls, and Susan's classroom generally gives the impression of a cheerful, busy place.

Susan

Susan, in her late thirties, has taught junior high and sometimes elementary school for about fifteen years, the last twelve at Pleasant View. She is married with no children, and is kept very busy teaching math and science, coordinating an extracurricular sports program, and helping to run a farm. Like Richard, Susan is highly regarded by administrators, colleagues, students, and parents for her teaching and extracurricular work with young people. Her interest in science was fostered by a female high school biology teacher who became the inspiration and model for Susan's teaching. After obtaining a university degree in biology, with earlier ambitions of oceanography or veterinary medicine put aside because of marriage, she entered teacher's college, studying high school biology and outdoor education. Practice teaching, and working with young people as a camp counsellor and coach showed that Susan preferred working with younger children, so she started her career teaching

elementary school, later turning to junior high. As with Richard, Susan's teaching was little influenced by teachers' college, but was very much shaped by a high school teacher she much admired, and wished to emulate.

Susan's approach to teaching is perhaps more "traditional" than Richard's. The desks in her classroom are arranged in rows, in keeping with a more formal style of instruction. The majority of student work is done individually at their desks, although practical activities are carried out in pairs or threes, with the desks moved together to form temporary groups. Susan strongly believes that a balanced approach best meets the needs of her grade 7 science students: a balance of individual and group work, of directed activities like note-taking on one hand, and more student-centered hands-on activities on the other. Considerable class time is devoted to seatwork such as organizing notes, preparing for upcoming lab activities, reading the textbook, and answering, correcting, or marking exercises or lab questions from the textbook. As with Richard, and many science teachers (Stake & Easley, 1978; Olson & Russell, 1984), socialization of students is an important commitment for Susan. Effective work and study habits, listening and comprehension skills—the "tools" for academic success—are a constant emphasis, and Susan is particular about how each assignment is to be formatted and carried out.

Susan is known to her students as a warm and caring, but very strict teacher. Her classes are under fairly tight control, and she insists on a quiet classroom and "no nonsense." As a result, there is relatively little chatter, "goofing about," or socialization while students work individually at their desks. All is very polite and subdued as long as she is in the classroom, and even when Susan was away from the classroom during my visits, the conversation remained muted and the behavior reasonable. "They don't like the way I react when they misbehave," Susan indicated, and with her strong will,

the use of rewards like food or drinks or permission to handle the animals in the classroom, as well as sanctions like detentions, or reversion to more boring routine seatwork, her students toe the line.

Susan's conception of "learning" in science has several aspects. Firstly, learning is acquiring and applying knowledge: "it's not all memorization of fact; it's taking what you know and applying it." But applying scientific knowledge means not just the academic sense of applying concepts in answering textbook or test questions or in class discussions. It also involves understanding and using knowledge in practical activities like designing experiments, model-building, or technological problem-solving, in doing or making something. Furthermore, for Susan, learning science is affective as well as intellectual and practical. It means that the students should feel good about themselves and the subject matter:

it (*learning science*) should be a positive learning experience, and I think it's important that they know what they're doing and why they're doing it—to have some confidence, to realize that it's not that difficult, that's it's fun, that it's exciting, that what they know they can apply and expand on.

Susan teaches two classes, 7M, with 27 students, and 7N, with 30 students. Both classes are heterogeneously grouped, with a balance of boys and girls, who seemed like well-dressed and decorous suburban 12-13 year olds. There are few visible minority or ESL students in 7M or 7N, and this particular year, no physically or mentally challenged students are integrated into her science classes. Here is how Susan describes her grade 7 students: "You have to remember the age of these kids, they are coming out of grade 6 and they are very 'me-oriented'. You can't talk to them as adults because they don't respond as adults..they're still kids,... just a child in a big body." To work successfully with this age group, Susan feels that an understanding of who they are and "where they're coming from" is crucial. Because the students are at a

concrete stage of intellectual development, they need a lot of "hands-on" activities, but at the same time they need structure and discipline: "you have to keep them on-task; they're so much happier when they know the rules and they know what they can do and what they can't, and they're happy because they come in and they're busy." As well, Susan places importance on recognizing and teaching for the diversity of learning styles and personalities among her grade 7's. Some work well in groups, while others do their best working individually, and all need much development of basic academic skills and work habits. For this reason, Susan tries to use a balance of approaches: individual and group work, bookwork and hands-on activities, projects, debates and so on.

Susan tends to arrive at school quite early, between 7:00 and 8:00 AM, either to get ready for the day's classes, or for meetings. Apparently there are many meetings at Pleasant View, arising from the need for conferences with on-site specialists about special needs students. Like Richard, Susan teaches both math and science—science and math to two grade 7 classes, and math to one grade 8 class, with a prep period or two daily (extra preps for being the school science coordinator), and one weekly noon-hour supervision. Since the junior high grades at Pleasant View Junior high are on a rotating timetable, each day is different. But every day Susan spends a great deal of her time before and after school, during lunchbreaks and weekends, giving extra help, running various projects, coaching, supervising detentions, and otherwise spending time with students.

Researcher's Relationship with Participants

Part of the relevant context of an interpretive study such as this is the researcher's relationship with the participants. How well did the researcher get to know the participants? What was the nature of the relationships? How might the

interpretations be biased by the researcher's relationship with, or attitude towards the participants?

I first encountered Susan when I met her at her school to request her participation in the study (she was the only grade 7 science teacher at this particular school). It soon became evident that we had remarkably similar backgrounds and orientations. We both attended academic high schools in the same area of the same province, took the same high school courses, and attended the same university at the same time, with identical career ambitions: oceanography or veterinary medicine. We took the same courses in the honors zoology program from the same professors, although we never encountered each other at the time, as it was a large university, we were in different years, and had different extracurricular interests. After completing university, and finding that neither oceanography or veterinary medicine had suited, Susan, like myself, pursued a post graduate B.Ed. specializing in high school biology and outdoor education, at neighboring universities. After that, our paths diverged somewhat, although we both taught elementary and junior high, worked with young people in sports, and maintained our interests in animals and biology, albeit in different ways. Allowing for differences in personality, my approach to teaching and learning when I taught junior high was, not surprisingly, fairly close to Susan's, in terms of a fairly structured style, and an emphasis on discipline, work habits, understanding and application, skills, and so forth. We got to know each other fairly well over the eight-month period of the study, with four recorded conversations, many informal conversations, and about two dozen classroom visits. But our conversations did not reach the depths they might have, perhaps because we lacked a common theoretical vocabulary. A very busy schedule and repeated illnesses on Susan's part may also have constrained the development of a deeper conversational relationship.

What surprised me was that I was not as comfortable in Susan's orderly classes (which a few years earlier I would have considered ideal) as I was in Richard's noisier, more informal cooperative learning classes. After forsaking school teaching for college teaching, taking graduate courses in curriculum, and re-examining my previous ideas about teaching and learning, I found that I had diverged somewhat from my former ideas about teaching. On the other hand, while Richard and I had very different backgrounds, we had somehow converged more in our thoughts about teaching. I first met Richard in a graduate curriculum course, and we became quite friendly, working in groups together, sharing ideas, and getting to know each other. Richard was much younger than myself, with a very different academic background (no biology, which he hated), and different interests. But when he heard about my study, he volunteered immediately to participate, as he would be teaching grade 7 science the next school year, was interested in my study, sympathetic to the goals of the junior high science program, and looking forward to a chance to continue our dialogue and reflections upon teaching and learning. Because of common theoretical backgrounds, vocabulary, and ideas about teaching and learning, the recorded conversations with Richard were perhaps more reflective and theoretical.

Teachers' Experience of Curriculum Change

What follows is an attempt to bring to light a sense of Susan and Richards' lived experience of a new Science-Technology-Society curriculum. The account is an attempt to convey some of the richness of the teachers' experience of classroom life by the use of descriptive and analytical language. Although phenomenologically oriented, the account does not restrict itself to interpreting the concreteness of everyday experience, but goes beyond the everyday to try to situate Richard and Susan's experience of curriculum change in the context of the larger society.

The findings, mainly drawn from transcripts of conversational interviews, with occasional references to observation fieldnotes, are organized around four themes: *feels right, right answers, the right stuff*, and *making it right*, through which I explore other phenomenological themes such as sociality, authenticity, temporality, freedom, alienation, and pedagogy. Quotations from data sources were chosen not only as apt illustrations of themes, but equally to give the reader direct access to the text being interpreted, to let the words of the teachers "speak for themselves."

"Feels Right "

Humans are social beings. Social life, regardless of setting or circumstances, is what grounds us, bounds us, and sustains us in everyday life. Accordingly, being a teacher or a student means experiencing classroom life primarily as a form of social life. To spend six or more hours a day, in a classroom with thirty or so energetic adolescents—relative strangers, non-volunteers, often with very different perspectives from yourself, belonging to social linkages from which you as an adult are excluded—is to experience a particular kind of sociality.

Learning in simpler times occurred as a shared responsibility within the family or the tribe, but the growth of specialization and the needs of a more complex society called for the teacher to stand *in loco parentis*, to hold responsibility for their pupils' learning, not to mention their deportment, behavior, health, and safety. Being a teacher entails a special kind of adult-child relationship, in which the teacher is assigned responsibility for other people's children, in order to nurture their growth towards adulthood. Yet even though teacher-pupil encounters may differ in some ways from other forms of human interaction, there is much correspondence with human social life generally.

For instance, Richard and Susan's talk about their experience of curriculum change was laced with reference to comfort, enjoyment, and interest. They had the sense that in their daily social lives with 12-13 year olds in the classroom, the new science program "felt right," particularly when contrasted with the previous grade 7 program they had taught for a number of years. For Richard, being comfortable in his classroom is an important aspect of being a teacher:

There definitely is a comfort factor. If I'm ever in the position of being caught doing something I don't like, I'm going to stop doing it. But I really like going into the classroom in the morning, I like being there.

The comfort factor he speaks of is mental well-being, an ease of mind in relation to the social interaction of the classroom. It means Richard "like(s) going into the classroom in the morning," that for him, being there feels pleasant, free of those distressing features of classroom life which can often spell an end to a teaching career, such as feeling afraid, ashamed, awkward, frustrated, guilty, inadequate, incompetent, or unliked.

Feelings of discomfort can, of course, arise in any social situation. But when a new curriculum is introduced to a junior high classroom, where the teacher has a certain status and credibility to maintain, where the teacher feels hemmed in by demands and constraints, and where the students may constitute a large, vocal, and often critical majority, there is undoubted potential for such feelings to arise. A constructivist-oriented STS course involving groupwork and many activities demands that teachers at least partly relinquish their place at the blackboard. Richard and I talked about this new role as a facilitator of group activities:

Q: You spend a lot of time now strolling around watching kids work, instead of being at the board with a piece of chalk. How comfortable are you with that?

A: I'm a little surprised at how comfortable I am. *(Pause)* I'm not totally comfortable with it. To be perfectly honest, standing at the front of the room, talking, being in charge of the

situation is very comfortable for me, and I know that's totally inconsistent with everything I've said about what I believe in education. There's a security in it. I know that I know my stuff, and I know that I can present it in a way that is clear, although I don't know how much the kids pick up of it, but I am more and more comfortable with this (*facilitator role*).

And later:

I am kind of comfortable with it, wandering around. I still get to be the expert and the owner of the knowledge. I need that, I guess, for my ego. Plus, I've got no right to be in the classroom if I can't make some sort of claim to knowledge. I like giving the kids a chance to explore, because I like piddling around with things until I can make them work. As long as the kids are enjoying what they're doing, I'm reasonably comfortable.

We see here that being comfortable in the classroom with thirty junior high school students has several dimensions. The didactic pattern of classroom interaction—the teacher standing at the front of the room—is an accustomed role, representing security, stability and confidence. After sixteen or more years of being taught in a like fashion, and six years of such teaching, it is as familiar and comfortable as a favorite old pair of shoes; there is little ambiguity and danger here. "Being in charge of the situation," at the front, doing the bulk of the talking, speaks to the power and authority which a teacher necessarily exercises over his or her pupils. Although the teacher is, in a sense, a volunteer, students are required by law to be in the classroom, at a particular place and time, learning particular subjects, with or without their blessing. Does not this didactic mode of teaching both symbolize and reinforce the teacher's authority, which stands between comfort and potential chaos?

Further, there is comfort in the confidence and security that comes from being "the expert," the "owner of the knowledge." In many social situations, possessing more knowledge than others present does not necessarily imply greater feelings of confidence and comfort. But to the extent that the teacher's role is conveying specialized "expert knowledge" to students who do not possess it, knowledge stands to

legitimize the teacher's authority and role. And, as Richard says, "I've got no right to be in the classroom if I can't make some sort of claim to knowledge." Knowledge is a large component of a teacher's credibility and competence. Those who have taught extensively know that teaching a new or unfamiliar subject can be very uncomfortable. One is nervous, fearful of being exposed as an imposter, of the questions that go beyond one's limited knowledge, of making mistakes, of appearing foolish and incompetent in public. "Knowing that you know your stuff," as Richard puts it, and knowing that you can present it clearly, strengthens those feelings of self-esteem and self-worth which can often take a battering in teaching. "I need that ('to be the expert and owner of the knowledge') for my ego."

When knowledge interactions in the classroom are placed on a different basis, such that students and teachers are active co-creators and co-owners of meaning, Richard finds that he is "not totally comfortable with it." For this is an unaccustomed and unfamiliar experience, away from the teacher-place at the front of the room, less the exclusive owner of knowledge, less in charge, and doing much less of the talking. As Richard walks around the room, observing, monitoring, and occasionally interacting with kids, there is a lingering unease with the novel role and interactions.

But Richard adjusts to the new way of being, "a little surprised at how comfortable I am." The unfamiliar becomes familiar; authority and credibility remain intact. And more significantly, his pupils' obvious enjoyment of the work confirms his growing comfort with a different order in the classroom. "As long as the kids are enjoying what they're doing, I'm reasonably comfortable." With this, Richard makes visible yet another aspect of a teacher's life with children. Is learning to be a grim, cheerless business for young people? Or is it to be a joyful experience, a natural part of those qualities of enthusiasm, freshness, wonder, exuberance and delight that draw us

as adults to the young. For Richard, "the joy of learning" is no mere cliché, but a necessary condition for his ease of mind as a social being living a classroom life with children.

There is more than this, of course:

You see the kids are enjoying it, and their academic performance is no worse than it was before. I don't know if it's any better, but it's certainly no worse than it was before. That fact makes me more comfortable with it.

Teaching science is not just a social interaction, nor just any kind of adult-child interaction, but an educational interaction, wherein the teacher holds a special responsibility for the maturation, growth, and learning of young people (van Manen, 1979). The fact that the students' academic performance is no worse than in the previous science course when less joy prevailed in the classroom, means that Richard is upholding his responsibility for students' academic success as one criterion of growth and learning. However, it seems that the formal pen and paper aspect of "academic performance" is only part of Richard's responsibility to educate his pupils. That they should experience classroom life as children, with childlike wonder and delight in encountering their natural world in a social way, is an equally strong commitment.

Susan has similar feelings about the curriculum change:

Q: So are you comfortable with that switch from the expert with the answers, to more of a facilitator?

A: I think...I'm happy with the change: I don't like standing in front of kids and watching them go to sleep. You can do it, but there was so much book work (*in the old program*). This way there is a lot more interaction.

Q: In a class like today's class, were you pretty happy walking around and watching the kids work?

A: Yeah, and helping them, and encouraging them.

Q: You'd sooner be doing that than standing at the front and writing notes on the board.

A: Oh, absolutely. But that has its place—they need to learn to do that and they need learn to take notes, to learn comprehension, and other skills. But they need a lot more of the hands-on, and this gives them the opportunity.

Susan contrasts her present comfort with a more facilitating role, to her discomfort during the earlier wholly content-driven grade 7 curriculum. Watching kids go to sleep is an uncomfortable experience, both a personal and a professional affront. To be unable to sustain others' interest in a social situation where one is doing most or all of the talking—being an obvious bore—is an attack on one's self esteem. But also it strikes at one's professional competence to be unable to engage students in learning, and as a caring adult and teacher to be unable to animate those very ways of being that draw us to children.

The activity referred to above, "in a class like today's class," was from the science and technology unit of the program. Students in small groups were designing ways to carry out simple tasks like transporting a small amount of water or removing a marble from a cup, using everyday materials such as plasticine, tape, straws, styrofoam cups, and so on. Over the course of a double period, Susan moved around the room, observing each groups' progress, encouraging, and helping where necessary. The students seemed very interested and engaged the whole time, seemed to understand what they were doing, saying things like, "Miss G., this is fun! Can we do more of this?" Susan enjoys this interaction, is comfortable being able to assume a more helping and caring role, and at the same time faces less unease about her pupils' educational needs ("they need a lot more hands-on"). The old grade 7 program lent itself more to "book work," such as reading the text, answering questions from the text, and taking notes from the board. It was rather abstract and difficult for many students, and made the provision of hands-on activities problematic. Conversely, the new STS course, with a different style of textbook, seems to give Susan's students an

opportunity to understand and use knowledge in practical activities, to have positive learning experiences in which they achieve success, have some fun, and feel good about themselves. Susan is more comfortable with the new STS program as a teacher because it promotes a kind of learning that is not only more consistent with her conception of learning science, but also with Pleasant View School's vision of a school where "people and process are more important than content."

On the other hand, Susan realizes from her involvement with the pilot program, that not every teacher feels this way about technological problem-solving activities in their classes: "you can get out of doing a lot of the activities too, there's always a way around it. If people are more comfortable doing it the other approach, they can, to some extent." Susan underlines here the significance of comfort for the introduction of change to schools. Like all of us, teachers will, if possible, tend to minimize risk, threat, unease, discomfort, and displeasure, while trying to strengthen feelings of self-worth, security and enjoyment in their daily lives. Whether from personal reasons of insecurity, or from professional conviction that this is not "real science," genuine learning, or proper teaching, discomfort with this curriculum innovation may lead some junior high teachers to find ways around it, to seek a more comfortable type of classroom experience.

A substantial element of classroom comfort for Susan and Richard is personal enjoyment and pleasure. This enjoyment seems to have several facets: a pedagogical satisfaction, a pleasure at young peoples' growth and learning, an enjoyment of students' own enjoyment, an enjoyment of dialogue and interaction, and a personal sort of enjoyment in doing something worthwhile. We see this in Richard's thoughts on the science and technology unit:

I really like the unit, because of the demand all the way through that the kids be thinking about something. Every thing is oriented to: "here are some basic facts, now go out and

apply them." I like it, and when I'm able to ask a question and have the likes of Robby, or Kevin throw up their hand—they have thought of a response, I mean that's amazing, and I like it on that account.

Q: So you react strongly to how the kids are enjoying an activity.

A: Yeah, that's one of my major concerns. If these activities become a burden, then they are totally self-defeating. That's one of the trade-offs—I have to be careful when I assign the write-ups. If I put so much emphasis and am so picky that the write-ups become a burden, so that the kids don't want to face an activity because of the write-up that they face afterwards, then the purpose is totally defeated.

Richard likes teaching this topic because the program seems to promote thinking and the application of basic facts, two cornerstones of his beliefs about teaching and learning. He gets pedagogical satisfaction from the fulfillment of his expectations about what his students might learn, and is gratified to see and participate in individual children's growth. Robby and Kevin, for instance, had typically been passive or disruptive in class, idle, and "low achievers," often sitting by themselves at a table in the front of the room. During various activities in the science and technology unit, their obvious engagement and participation, their worthwhile contributions to discussion, their eyes shining, posture erect, hands waving high, are concrete grounds for satisfaction, and for hope about what they might become.

Richard affirms that children's' enjoyment is one of his major concerns, while bringing to our notice one facet of the tensionality that marks classroom life. Tensionality refers to that mode of experience framed by lived tensions, dilemmas, or contradictions. In teacher-child relationships there are always dilemmas, some arising from opposing conceptions, values or beliefs the teacher might hold, others that simply inhere in the situation. Here Richard is referring to the tension between the present and the future, between here-and-now enjoyment and the longer-term learning goals represented by lab reports. If he insists on presentable, well-organized, thoughtful lab

writeups, his pupils may improve work habits, develop useful academic and scientific skills, and gain more knowledge through thinking and writing about the activities they perform. But for this class (7X), who are not particularly motivated to do written work, this is an important but not overriding concern. What counts for this group of young people who have not experienced learning primarily as success, enhanced self-image, or joy, is that they continue to have a positive experience of learning.

Susan too, finds pedagogic satisfaction in her classes' learning and enthusiasm during the science and technology unit:

The way they applied what they had learned to the questions was really rewarding, they learned a lot more than I anticipated. Some of that came from just doing this final activity (*involving the design and building of a complex structure of straws, paper clips, etc.*), and I'm sure that it's one of the best activities there. I like to build it up, because they do look forward to it and when they do get to do it, their enthusiasm is such that, they are well into it.

Q: You mentioned that you liked it. Is that important? If a teacher didn't like it would that affect what they do?

A: If (a teacher) wasn't comfortable with something, they would tend to spend the minimum amount of time with it, and spend more time on what they know well. Over time, though, they would become more comfortable with it—the discomfort will dissipate.

Susan enjoys her pupils' interest and enthusiasm, and furthermore, recognizes its importance to learning. That is, when subject matter has intrinsic worth in terms of its ability to capture attention and engage minds ("they are well into it"), strategies for promoting on-task behavior are not needed. She further underlines the connection between liking, being comfortable and possibilities for change in science teaching ("they would tend to spend the minimum of time on it").

Meanwhile, Richard tells of his own personal enjoyment of the course, and the part that plays in the success of his teaching:

I like the course, although it is an area of particular personal weakness, I got a lot out of it and enjoyed it. That surprises me, that I'd have a good time.

Q: You enjoyed the biology parts of the program, even though you're a non-biologist who hates biology?

A: That's a sign of a good program, when I enjoy the parts I hate.

Remember that Richard sees himself primarily as a mathematician, who took first year physical science courses in university, but feels that science, particularly life science, is an "area of personal weakness." Enjoyment of learning has always been important for Richard: "I take courses because I like taking courses, and I enjoy learning the things in those courses—gee, that's something fun!" But he always had hated biology:

That stems back to biology 10. I hated it, I never pursued it. There were a couple of projects and assignments, I recall thinking at the time, were completely meaningless. It must be this—I've never really analyzed this before—but it had absolutely no relevance to my life. I learned how to classify fish, and I learned how to recite kingdom-phylum-family, etc. It was just so awfully irrelevant. Not that physics is more relevant, but physics I at least found interesting and could find application as soon as I walked out of the classroom. And chemistry the same thing: I now know what the sugar is doing in my coffee, et cetera.

We see that to enjoy learning, a learning experience must have meaning for us in terms of our own lived life. What constructivist psychology tells us (von Glaserfeld, 1991), we can also recover from reflection upon our own experience, as Richard has done: learning is a process by which learners actively construct meaning from personal experiences of the world. Being "awfully irrelevant," like Richard's fish classification, simply means that there are no points of contact between his lived experience and the biology content, hence it is meaningless. No genuine learning takes place. Neither joy nor pleasure, but rather frustration and anger, are associated with the subject matter, and because he experiences biology in this negative way, he thereafter hates and avoids it. Despite all this, in the context of a science course shaped by constructivist notions of learning, Richard now enjoys biology, since he "got a lot out of it" and "had a good time." Biology had somehow become meaningful and relevant for Richard, as well as

his pupils, enabling him to create his own personal meanings for biological phenomena, and to experience the unexpected joy of discovering a new and previously inaccessible way of looking at his lived world.

There is more to it than that, however. This is how Richard clarifies an earlier draft of my interpretation of the passage quoted above:

Now that I'm a little further from this statement, I think that my reasons for enjoying the biology portions extended beyond the fact that the kids enjoyed it more. It has more to do with the fact that for the first time, I saw biology as a process rather than as a product. My Biology 10 experiences of memorizing everything between pages 16 and 842 was put aside in favor of a more "how do we come to know?" orientation, instead of "what do we know?". I was thus able to import some of my physics, chemistry and math enthusiasm into biology.

Later, we shall return to the idea of science curriculum as process rather than product, but let us for the moment pursue the notion of enthusiasm that Richard speaks of.

Interest is an aspect of intentionality, or what consciousness is directed towards, that is often taken for granted in educational discourse. The word "enthusiasm," today meaning "an intense interest," finds its origin in the Greek word "enthusiasmos"—possessed by a god. The dictionary also tells us that "interest" is a state in which curiosity is excited, attention is held, and knowledge is desired. When we talk of learning science, it is the physical world that presents itself to the ego, and possesses our thoughts, our feelings, and our actions. At the same time, we somehow project ourselves into that world in a reciprocal fashion, such that we are in the world, but the world is also in us. Being interested means whatever has possessed us rouses our curiosity and our desire to know more of it.

What concerns us here, of course, is how this relates to children. Sarason (1990) reminds us that "if there is anything that we can say about the biologically intact

pre-school child it is that he or she is a question-asking, question-answering, questing, knowledge-pursuing organism, pursuing knowledge about self, others and its world" (p.157). It is also an unfortunate commonplace that for many children this natural curiosity, questioning and interest in their world is progressively diminished by their encounter with formal schooling. But Richard recognizes that an openness to the world persists among his grade 7 pupils:

Q: And you find that kids this age (*12-13 year olds*) are interested in, uh, interpreting data?

A: Well, I think kids of all ages are interested in finding the answers to interesting questions. So, yeah, they're into interpreting data, and making their own theories. I don't know what makes them (*questions*) interesting—it's just something that appeals to them. I'm probably the world's worst guesser as to what would be interesting to grade 7 students. I wish I could figure out what makes a topic interesting, that would make it a whole lot easier.

In actuality, curriculum theorists, teachers, and others involved in education have often lost sight of the fact that for young people, interest, curiosity, and a desire to know are inherent ways of being. Children (of all ages) are naturally captured and engaged by appealing questions about their social and physical worlds. It is said that scientists are adults that have never lost their childlike sense of curiosity and wonder. Likewise, the "science inquiry skills" emphasized in many science curricula, are essentially the formalized, systematized refinements of children's questioning; the grown-up's equivalent of the preschooler's insistent "but why, Dad?". To inquire into the natural world—to do science—should be an intrinsic and unexceptional mode of being for junior high students. However, I think it is safe to say that adolescent students typically have not experienced school learning, including science, as interesting, stimulating, and meaningful, in the sense that it answers their myriad of questions about the world, as opposed to the teacher's, textbook writers', or curriculum planners' questions. Richard sees that a fundamental interest in their lived world is still immanent

among his pupils, as long as the questions asked are interesting, that is, make sense in terms of their lived experience and their expectations.

Now exactly what makes a particular scientific question or topic appealing to grade 7's, neither of us is sure. Richard likely underrates his ability ("world's worst guesser") to identify what would interest his pupils and to what degree, but during his first experience of the new grade 7 program, he does encounter numerous surprises. It is probable that there are limits to how far Richard, or any adult, can enter a grade 7's world. But the teacher-authors of the textbook the class is using have some idea of what might be interesting:

Well it's twiggig their interest, and that's the first thing. If you want to get these kids to think, you have to find something they want to think about. Whether or not it's getting them to go to any great depth, I don't know. I have no basis of comparison—this program is in such contrast with the old program where we didn't expect them to think much: "you memorize these parts, and list these things in the right order." There weren't a lot of questions that were testing their thinking powers.

With this, Richard appears to derive a basic insight from his experience in the classroom: interest first. He sees that thinking, in its various forms, is concomitant with young peoples' engagement by interesting questions about the world *they* live in. Take the case of Richard's 7X class discussing (for a whole class instead of the planned few minutes) an experiment performed by Niko Tinbergen to find out how digger wasps locate their nesting holes. As they analyze the experiment and interpret the given data in the text, the class reflect, reason, argue and point out flaws in others' arguments in their characteristic unrestrained manner. Even the brains of young Homo sapiens are wired for reflection, critical thinking and argument upon things which hold meaning for them, and attract their interest, concern, and attention. Our experience as children, teachers and parents attests to this. Is it even necessary to teach critical thinking and reasoning to children as if they were *tabula rasa* ; or is it only needful to

refine what already is present? The old program apparently did little to gain students' interest, and neither demanded nor stimulated thought, other than the mindless memorization of facts and lists. But Richard's experience of his pupils' interest in science in the new science program "feels right" to him. For the young people in his school life to be interested in the subject matter, to intend towards nature in a feelingful way, to engage in spirited dialogue with each other, is a fitting form of social life with children.

Enthusiasm, as we said earlier, is a kind of intense interest, or possession. It is something that we possess, yet possesses us. Not only that, it is also a possession that possesses the other, an interest that interests. This is plain to see in this passage from a conversation with Richard:

Q: How were the units that involved physics and chemistry?

A: I had a blast with them. They are both personal favorites—we went out into the parking lot, for instance, with a big cart from the gym to test forces and motion. We did a lot of interesting activities, and because I found it so fascinating, it rubbed off on the kids.

Q: Is that important that you found it interesting and stimulating?

A: If I can't find it interesting and stimulating, it's tough. Another course I teach is DEADLY. I can't project any enthusiasm, and the kids aren't enjoying the course because I'm not. But I refuse to say that if the kid isn't enjoying the course it's the kid's problem. I'm the leader, I set the tone, I'm a very major part of the course, and I'll take that responsibility.

When an adult such as Richard is able to enter the natural world around them, and say to the young, "look at this phenomenon, is it not wonderful," and "look at this in a new light," their world opens up too; they now dwell in a larger and richer world, and can share in the teacher's eager interest. Richard's interest in and fascination with forces, energy, and movement as a way of looking at the world, when focused on something as mundane as a cart in a parking lot, was contagious. But how so? The gym cart was already part of the students' lived world, moreover, Richard was able to reveal a fresh

view of the cart, that combined with an atmosphere of fun, movement, and lightheartedness, "rubbed off on the kids."

Teachers are obliged to be interested in and enthusiastic about their subject matter: BE ENTHUSIASTIC! is common advice for novice teachers, as if it were a matter of technique. But as Richard's description of his option course ("another class I teach") shows us, it is not as simple as that. Enthusiasm and interest are states of being, not techniques to be mastered. Why Richard cannot project any enthusiasm, and why all those in the classroom found the agriculture option course "deadly," is once again related to the question of meaning. The topics themselves would have little meaning for city adolescents (and I suspect most city teachers): "Produce Marketing Boards" and the "Price of Food," the "Abandonment of Railway Branch Lines and the Crow Rate," and the like. Since the subject matter is abstract and unrelated to our lived experience, the teaching reverts to the presentation of pre-packaged information, followed by the asking of questions about that information. It is not a world that we can easily enter, situated in a city classroom, nor is it a world that has any home in us. Those same students that earlier in the day in Richard's math and science classes were noisy, animated, and seemingly interested in the work, were, in agriculture, quiet, subdued and sullen, less willing to volunteer answers to questions or do the assigned written work, and in receipt of more admonitions that "this is for marks." In this situation, the teacher—still responsible for the learning that does or does not occur—is reduced to unconvincing counterfeit enthusiasm, but nevertheless, the subject matter remains un fascinating, if not hateful, to all involved.

We have been considering classroom life as a form of social life. Dewey (1916/1966) writes, "not only is social life identical with communication, but all communication (and hence all genuine social life) is educative" (p. 5). To participate in

communication, he says, is to render an experience meaningful to others, so that through reflection we come to look at our own experience in a different way. Thus social life, in its enlargement of experience, in its stimulation of the imagination, and in its making possible the eliciting of meaning from life, is educative. In formal education in particular, Dewey looks upon the relation between teacher and student as reciprocal: "the teacher is a learner, and the learner is, without knowing it, a teacher" (1916/1966, p. 160). This is much in sympathy with Freire's notion of education as *dialogue* (1989), an encounter in which students and teachers are co-inquirers with joint responsibility for growth—educational partners who teach each other. Dialogue implies a conversation, an interchange of meaning by people in search of mutual understanding. It stands opposed to what Freire calls "banking education," the familiar system in which teachers (who supposedly know everything) "deposit" knowledge into passive students (who supposedly know nothing) for memorization and repetition. In reality, banking education embodies *monologue*, which negates the idea of education as intersubjective and reciprocal; as reflective and meaning-making.

Often—too often—the science classroom has been the realm of the monologue. A banking approach to education, suffering from what Freire (1989) identifies as "narration sickness," has typified science education, despite efforts at reform in the last few decades (Cuban, 1984; Goodlad, 1984; Tomkins, 1986; Welch, 1979). To be sure, there is two-way traffic in science classroom discourse, but as numerous studies confirm, this is mostly in the guise of question-and-answer methods intended to direct students towards existing "expert knowledge" (Barnes, 1976; Geddis, 1990). Yet in the context of a new junior high curriculum, both Richard and Susan find possibilities for dialogue, for different forms of classroom communication.

Susan:

There was so much book work (in the old program) This way, there is a lot more interaction.

Q: So, in terms of your teaching methods, have you changed from what you used to do?

A: Oh yeah—to some extent. A lot less lecturing, a lot more discussion, a lot more getting the kids involved, and having them dialogue. And they will, and they'll argue.

Whereas before: this is the way it is, and here it is, so do it!

Q: This is the right answer, and no discussion.

A: There wasn't. There were no issues, and you didn't learn that there could be two answers to a question, and that yes and no could both be correct.

Susan finds her classroom has become a more vital, social place. "Interaction," "discussion," and "getting involved," are dimensions of dialogue as a social activity. Humans, young and old, are communicative beings; to talk, to listen, to stimulate each other to think, to create and re-create meaning, are at the essence of being human (Freire, 1989). At the same time, we see that dialogue entails an epistemological position. "Whereas before: this is the way it is" meant that knowledge was expert, fixed, unquestionable. There was only one right answer to a question, and this belonged not to the students, but to the teacher, the textbook authors, and the scientists. Conversely, in a more dialogic classroom, Susan finds that knowledge can be a common possession of those in the class, socially constructed and more open-ended, with multiple right answers. Pupils and teachers can both teach and be taught, and while the teacher loses some control of knowledge, she gains in other ways.

Now Richard:

One thing I really like about this course is that it demands that you be interactive with the kids, and that's where learning takes place, in that interaction, and why teachers will never be replaced by computers.

Q: Hard to make a monologue of the program?

A: Impossible!

While perhaps being overly sanguine about the possibilities for adaptation of the program in more didactic directions, Richard perceives that the grade 7 science course

recognizes the social nature of learning. He believes that learning is a natural outcome of human social interaction, that, as Dewey said, communication is educative. Those who teach know that, as we reflect upon subject matter and our own experiences in order to communicate more clearly with students, we discover anew what we know, come to see things in new ways, and enlarge our lives. Often we come to truly and deeply understand something for the first time when we are faced with teaching it. Why should this be less true for students? When all that is required of students is the back and forth exchange of fixed knowledge, there is little incentive or opportunity to fundamentally communicate and re-learn what they know. In conversation—by necessity, unconsciously, and almost effortlessly—young people will reflect upon knowledge and experience in order to think out loud, affirm, or argue. This was evident in the classrooms I visited in the study, as well as in my own experiences as teacher and learner. In genuine classroom dialogue (but not lecturing or idle chatter), as ideas and experiences are shared and thought about, meaning is created and reshaped, and common understandings arise. So students teach both themselves and others, including the teacher; "learning takes place in that interaction," as Richard says.

Of course, Richard has been influenced by his graduate studies in education, involving classroom research on childrens' talk and learning mathematics. But his commitment to classroom dialogue goes beyond the merely intellectual. His room is arranged in clusters of desks, and he teaches both his math and science courses through cooperative group work and class discussion. More than this, dialogue seems to be part of his quest for authenticity in the classroom:

I try to be very much myself in the classroom; teaching is a reflection of myself. It feels natural in the classroom, not like I'm staging anything in there, and at one time it did. I'm talking to you now like I would to a student.

In becoming a teacher, especially, it is difficult to know who you should be. The beginning teacher is burdened with previous role models, metaphors, folklore ("don't smile 'til Christmas") and expectations. The very last person it seems you should be is yourself—inexperienced and inadequate. Earlier in his teaching life, Richard felt like he was "staging it," assuming a role or persona that was not strictly his own. Within a monologic, didactic style of teaching, it is relatively easy to assume such roles as "the academic expert," "the authoritarian," and so on. But in the last few years, as Richard has re-thought his ideas and values about teaching and learning, he has come to see teaching in a different light: teaching as a reflection of self. In other words, rather than playing a specific teacher-role ("staging it"), he tries to be a real flesh-and-blood human being in the classroom, a situation that releases teacher and students from particular performances, so that "it feels natural in the classroom."

The authentic person, according to Sartre (Anderson, 1979), accepts himself in his situation as it actually is, and accepts the responsibilities this involves. Teachers who strive for authenticity, having accepted themselves as they are, and their situation as it is, without self-delusion, try to live and teach accordingly with thought and action as consistent as possible. Not to say that such an undertaking is always successful, but that this is the direction pursued. And to accept oneself, and one's being is also to accept others and their being (Anderson, 1979), to turn from monologue to dialogue. Authentic education, in Freire's words (1979), "is not carried on by A *for* B or by A *about* B, but rather by A *with* B," and hence exists when people are engaged in the horizontal relationship we know as dialogue. Richard sees dialogue as a form of genuine human social life, unlike lecturing or questioning strategies. As I could see during classroom visits, he tries to be himself in his classroom, and talk *with* his pupils as he would with a peer. All the same, there are constraints on dialogue in a 45

minute class with 30 boisterous junior high students, and a limited amount of time. But striving for more authenticity and dialogue in his classroom allows Richard to feel good about himself and his students.

To this point, we have tried to bring forth some elements of Richard and Susan's experience of a constructivist oriented science curriculum in their classrooms. In contrast to the traditional content-based science courses they had been teaching, they experience more comfort, enjoyment, interest, dialogue, a more fitting form of social life with children. But what is it that makes this possible? How can a set of ideas, a curriculum document, textbooks or other materials, apparently transform life in the science classroom? We turn now to this question.

"Right Answers"

The subject of freedom...has now become the paramount issue of our time (Barrett, 1979, pp. xiii).

The subject and meaning of freedom are no less a concern today, than when Barrett wrote these words. On the contrary, within the industrialized countries of the West, as well as in the ex-Soviet bloc, in South Africa, and elsewhere around the globe, the implications of freedom in its various guises are still being worked through. On one hand we have "democracy," "free enterprise," "free market," "free trade," "freedom of speech," and on the other, homelessness, unemployment, increased polarization of socioeconomic circumstances, and a deeper penetration of technology into our lives. Undoubtedly, over the last few centuries many societies have become more "democratic," achieving freedom *from* tyranny, overt social control, and basic biological deprivation. But there has been a strand of thought (Barrett, 1979; Freire, 1989; Fromm, 1955; Marcuse, 1964) that suggests that, in many ways, we have failed to achieve positive freedom, a freedom *to*.

In this sense, freedom is about choice in thought and conduct, about freedom to become more fully conscious and human; a freedom that inevitably means responsibility, risk, and insecurity (Barrett, 1979; Ellul, 1986). The growing domination of our society by technical rationality and its economic system has resulted in what Marcuse calls "a comfortable, smooth, reasonable, democratic unfreedom" (p.1, 1964). For technical rationality is the antithesis of freedom, a flight from the freedom of a chaotic, indeterminate world to the simplifications of a Newtonian clockwork universe (Barrett, 1979). At the philosophical, ideological and practical levels, many people in our culture are afraid of freedom, of its responsibilities, and its essential insecurity, and retreat unconsciously into the certainties of fundamentalism, consumerism, behaviorism, or conformity. Hence our democratic unfreedom: the contradiction of freedom of speech and movement, when human minds are unfree—enshakkled by technology.

As in the larger society, the issue of freedom relentlessly confronts the teacher in the classroom. Our lived experience as teachers is framed by choices to be made and by the responsibility for their consequences. In the present study, the theme "right answers" suggests that with the arrival of a new science curriculum, the horizons of classroom life have widened in a number of ways for Susan and Richard. In the first place, Richard finds that for him, the learning expectations of the new program are less well-defined:

The curriculum objectives are very much different from before; they are very—airy-fairy, loose, hard to nail down, a little bit fuzzier than they used too be, and necessarily so. It's difficult to say "yes I've accomplished that" when it's something that carries on the whole year, and I think that's the case with most of them. "Yes, I'm working on that," I can say about just about anything in the program of studies, but "yes, I've accomplished that," I can't say, which I could with the old program. You really can't check off points the same way with this program.

The new curriculum outcomes are perceived as "fuzzier" in that they encompass more subtle attitudes, skills, and concepts, while the old program had become a well-defined list of facts to be memorized, tested, and checked off. What we notice here is the posing of two epistemologies against each other. Firstly, the old program embodies positivist notions of how we stand in relation to the world. This is the Cartesian idea of "two worlds," in which the knower's world is separate from the single reality of a machine-like external world. The external world, because of its independence, can yield objective and value-free knowledge to scientific method. Moreover, such knowledge can be atomized into separate facts for convenient dispensing by teachers to students for memorization, testing and later checking-off. Against such a view lie some underlying assumptions of the new program. Its constructivist approach to knowledge presupposes that the student and his or her world are inseparable and interdependent, so that students, along with their teachers, are active constructors of knowledge. This must mean that, far from one fixed reality, there are multiple realities to be negotiated by the knowledge community in the classroom, resulting in some sort of common understanding. A measure of diversity is to be expected, given differences among students, teachers and situations, and the uncertainty of individual learning predicted by constructivist psychology. With this the case, and a greater emphasis on process and skills in the program, objectives are necessarily less well-defined than the lists of facts characteristic of the prior course. In other words, the new learner expectations are more consistent with a post-positivist world that is somewhat indeterminable, random, and subjective. This "fuzzier curriculum" seems to have a number of consequences for the classroom lives of the teachers in the study.

For one thing, there seems to be more flexibility and choice for teachers. This is what Richard has to say:

Another thing I like about the course is the flexibility to follow what you want. You can achieve the curriculum objectives without adhering to what's in the textbook, so the content has some flexibility, and that's nice. It's not one-program-fits-all, there's room for flexibility, it's built in.

It's definitely planning from day to day. And then, not planning in the way I planned science courses previously, so that I could pick it up and teach exactly the same course next year.

And I'm not even planning it the same for both classes, there are things I'm doing for one that I'm not doing for the other.

This passage illustrates that Richard is finding more right answers for teacher deliberation and choice. With more open-ended and process-oriented curriculum objectives, he is able to choose more freely among teaching and learning activities according to his own ideas about what is right for his students in their particular situation; there is room to "follow what you want." The built-in flexibility allows Richard to plan from day to day, to follow each class' particular interests and needs, to learn from one class and apply that learning to another. Because the teacher and students have a role in constructing their own knowledge and more free choice about which activities to do, the new course is unlikely to be exactly the same from year to year, or class to class, in the way that this was possible with a banking concept of knowledge.

Susan thinks that the curriculum "gives some parameters to work within." Instead of a list of pre-established knowledge to be adhered to, the curriculum provides a measure of freedom, within boundaries. She values this choice, and her planning, too, has changed:

Q: Do you plan down to the last detail, or play it by ear?

A: I play it by ear, and it depends on how the kids handle the lab situation. So I rough it in, but I don't plan down to the last detail, that's a waste of time. As long as I know where I'm going and what I'm doing, then as long as you're meeting the curriculum, the specifics you modify as you go along.

As modes of planning, "playing it by ear" and "roughing it in," are movements away from technical rationality, for which planning would consist of choosing the best means to achieve predetermined ends (Schön, 1983). When curriculum is highly specified and standardized, as in a content-based program, the teacher is, in effect, a technician, choosing instrumentally among relatively few alternative ways of teaching and learning the content. Taking a broader view, in this scenario the science teacher is a tiny component in the vast technological enterprise aimed at furthering human "progress" through the application of scientific knowledge. But in the passage above, Susan is describing a different "epistemology of practice" (Schön, 1983). This recognizes uniqueness and uncertainty in situations, rather than uniformity and certitude, and accommodates teachers' practical knowledge, as well as teachers' and students' explorations of knowledge. We find a lesser separation of ends and means, so that exact objectives and activities are determined situationally by the teacher: "the specifics you modify as you go along." Susan indicates that this non-positivist epistemology upholds her subjectivity as a person who knows what she's doing and where she's going. At the same time, she is aware of the responsibilities, such as "meeting the curriculum," that this professional freedom entails.

Freedom, flexibility and choice, however, are two-edged. Barrett writes, "the price for freedom is risk, uncertainty, and inevitably the measures of anxiety that accompany these" (1979, p.103). Thus for teachers less accustomed to curriculum choice, and more familiar with covering *all* the content objectives, a new openness produces time-content dilemmas. Susan describes these tensions:

It's extremely difficult with the amount of material and the interest the kids have in it, you just skim the top. That's my biggest bone of contention with the new program. The units themselves are incredibly interesting—doesn't matter which one, all three areas (*biology, chemistry, physics*) are covered well. I'd sooner see four units over the year (*instead of six*).

Q: The amount of material is a problem...

A: Do you water it down to the point where you do it quickly, then what are you doing? You're throwing it at them to get them through it quickly. Is the intent exposure, or a little more depth?

Richard is in the same boat:

It's difficult to time this course—to cram six weeks into four weeks.

Q: How do you balance following the curriculum versus following the kids' interests and doing an in-depth job?

Richard: That's difficult to answer. I find myself having to say, "spent enough time on this" too often.

Q: Before kids are saturated?

Richard: Yes. Like in the bacteria experiment, we could have spent three or four weeks instead of almost a week. It whetted the kids' appetites and brought up a whole bunch of questions they wanted to research more closely, and be more careful about how they asked the next question. It would have been a fabulous experience and exercise to go one step further and ask a better question, to control a few more things, fix up our errors, and do a better job this time.

The lived experience of time is something we are much aware of in the technological society. We are alienated from experience of time as natural temporal rhythms of night and day or season by those arbiters of modern life and necessities for industrial efficiency, the clock and the calendar. It is not too farfetched to accept the clock as a root metaphor for the scientific and industrial revolutions, and for their social-cultural implications amongst which we now live. Gitlin (1983) draws our attention to the industrialization of time and how school time mirrors the time of clocked labor. Learning in the industrial age, for instance, has been precisely moulded in the shape of the clockface, with its efficient packaging into 45-minute periods, 51-minute lunch breaks, 6 1/2-hour days, 5-day weeks, 180-day years, and so.

Bearing this in mind, greater curriculum choice means, for one thing, there are more ways in which the same limited amount of time can be spent by teachers and

children. With two textbooks and two teachers' guides to choose activities from, there are more learning activities available than there is time for. Moreover, Richard and Susan both find that their pupils are very interested in the curriculum materials. This in turn leads to a tension between addressing the demands of the curriculum on one hand, and going into depth to follow student interests and to foster thought and understanding, on the other. Despite the greater choice, both teachers seem to feel a strong professional responsibility to cover as much of the mandated curriculum as possible. Even in the relative absence of centralized control of teachers and curriculum in their school district, Susan and Richard feel strongly compelled to "cover the content." Why is this so? Perhaps this is one of the basic responsibilities accepted almost unquestioningly as part of the role of teacher in our society: keep attendance, keep order, attend to the basic health and safety of students, and cover the curriculum. Partly, it could be cultural conditioning. All have of us have spent many years in classrooms and lecture halls in which finishing the course, or covering the content, has been a fundamental concern of teachers, such that this ultimately becomes part of our own cultural baggage: "courses must be finished!" Additionally, the preparation ethic—the rightness of preparing students for subsequent courses and for future careers—is likely a strong part of this felt responsibility.

But underlying Susan and Richard's time-content dilemmas, are two more fundamental contradictions involving time. First is what we might characterize as the "industrial time—organic time" contradiction. Our human body, the result of 50 000 or more years of evolution in varied non-industrial environments, has its own natural functions and rhythms, its own timetable, but not independent of events in the natural world. Not only eating and sleeping, but also learning, operate independently of the timetables of industrial work and schooling. Working the midnight shift, or cross-

cultural encounters between people from an advanced industrial society and people from a pre-industrial culture, such as my own experiences with Northern natives ("crazy white man: he has to look at his watch to see if he's hungry"), can bring this into sharp relief. As Piaget and others have recognized, learning has its own timetable. But unlike the need to eat or sleep, it is neither linear nor predictable, but rather episodic, variable, and somewhat random. Some things we learn in an instant of insight, others may take months or years of application and determination. Furthermore, individuals differ in this regard. We do know that true learning—making sense of our world and gaining competence in our interactions with our environment—as opposed to rote memorization, takes time. Yet schools in our society have adopted a fixed timetable for learning, compatible with the needs of an industrial society. Consequently, curriculum authorities determine that certain things are to be learned by pupils at a particular age, within a particular period of time. And hence Susan's frustration with "throwing it at them to get them through it quickly," or Richard's difficulty with "cramming six weeks into four weeks." They are experiencing the lived tension between the organic timetable of learning, their students' own human needs and capacities, and the industrial timetable of learning, representing the needs of a technological society.

Our everyday lived experience is anchored in the here-and-now. While our memories, scars, and DNA bear witness to our pasts, and our offspring, hopes and fears project us into the future, our biological being lives firmly and inescapably in the present. Children, in particular, live and learn very much in the present tense. However, their teachers are responsible for, and conscious of, not only the present, but also the future. Will their students pass their final exams? What will their students know and be next year? Hence the second temporal contradiction, which every teacher

or parent meets constantly, between present and future. How many parents or teachers have said something akin to, "you may not like this now, but you'll thank me later," with regards to a music lesson on a summer day made for baseball with friends, or a seemingly boring and pointless assignment? In the passage above, Richard, finds himself saying, "spent enough time on this," too often, as the future contradicts the present.

In the bacteria experiment, Richard and his pupils spend several days investigating where microbes are found and their conditions for growth, becoming engrossed by scientific inquiry into their everyday world, and empowered by their ability to pose and answer questions, and create meaning. Both he and his students are absorbed with the here-and-now experience of learning. But not only the curriculum guidelines (33 days per unit maximum), but also the future needs of the student—the preparation ethic—are placed against their present need for adequate time to learn deeply and authentically. Will they suffer in further science courses, and possibly their future careers, if too little time is spent on a topic or if an entire unit is omitted? Like the organic—technological time contradiction, the present—future time contradiction is not a technical problem that Richard or Susan can solve, but a tension to be lived, a dilemma that must with difficulty be resolved for each unique situation, as humanely as possible, albeit with an outcome that is shrouded in ambiguity and uncertainty.

But it is not only the teacher's curriculum decisions that are now marked by uncertainty. The "right answers" theme also literally means that there is less often a single correct answer to a question; scientific knowledge in the classroom has itself become, to some extent, more ambiguous and open-ended. Susan sets her present experience of right answers against that of the traditional program :

You didn't learn that there could be two answers to a question, and that yes and no could both be correct.

Again, Susan is evoking two contrasting epistemologies. The oversimplified Newtonian worldview implicit in the old program accommodates a definite, fixed, certain right answer for each question, while the constructivism of the new program not only accommodates, but imposes pluralism and ambiguity upon the classroom. As is all too often the case in school science (Geddis, 1990), the old program perpetuated a distorted view of scientific knowledge which Schwab calls a "rhetoric of conclusions...a structure of discourse which persuades men to accept the tentative as certain, and the doubtful as the undoubted, by making no mention of reasons or evidence for what it asserts." (1962, p. 24). There was usually only one right answer—the one in the textbook, teachers' manual, or curriculum guide, which was presented and learned disconnected from any meaningful context of observation or argument. On the other hand, the new program requires that "concepts be introduced through a broad range of experiences," such as scientific inquiry and problem-solving, and that "students be given opportunities to reflect on their experiences, learning to discover and construct meaning through careful and focused thought (Alberta Education, 1990). Under these circumstances, Susan's students are able to discover that several right answers are possible, and that appeals to the evidence (rather than to authority), careful thought, reasons and argument are necessary to adjudicate among them.

Nonetheless, Richard and Susan are more accustomed to a teaching role defined by their being the authority for knowledge and the dispenser of definite right answers. Richard, for instance, finds he is less comfortable than his students with the uncertainty the new program seems to engender:

My students often seem very comfortable with ambiguity and open-endedness, more comfortable than I was expecting, because I'm a person that is really not comfortable with ambiguity in knowledge. There are a lot of things I can now leave totally open and say

"haven't got a clue here." There was a time when I couldn't do that—and I don't know if it was my discomfort coming through or that of the students. But they seem to be OK with the whole idea of "we don't know the answer," or "OK we can't find the answer to this."

Richard finds that his students are more at home with ambiguous knowledge than he is. No wonder, for, like you and I, Richard has been nurtured in a society embodying technical rationality, a society which seems to favor simple distortions over complex truths, and single right answers over ambiguity (Lewontin, 1991). In our schooling, university education, teaching experience, in the media, and in our culture in general, there has been very little to balance or counter positivist ideology. So, we are very comfortable with the simple and the definite, the fixed and the certain.

It was pointed out earlier that the role of the didactic teacher is to convey "expert knowledge" to students, and more significantly, that having this knowledge is an important aspect of the teacher's competence and credibility. In this situation, for a science teacher such as Richard to say "I haven't got clue here," or "I don't know the answer," could threaten his credibility as a subject matter expert, and make him feel most uncomfortable. On the other hand, Richard's grade 7 students have been exposed to fewer years of "right answers" in the classroom and society, still have something of their youthful openness, and stand to lose nothing from saying, "we don't know the answer." These young people are comfortable with the ambiguity and open-endedness that seems to accompany the new science course, while their teacher is becoming more accustomed to uncertainty.

Wider classroom horizons and uncertainty also mean that evaluation has become a major concern for Susan and Richard. In the past, evaluation methods for Alberta junior high science "tended to focus almost exclusively on the acquisition of scientific knowledge" (Mrazek, 1989). Science teachers typically used pen and paper tests

involving multiple choice or short answer questions, which measured discrete packages of information. But now, Susan finds that :

I'm having a great deal of trouble formulating an evaluation form that's fair. I think that's probably the most difficult thing in this curriculum.

You can't evaluate totally on paper, you have to evaluate them on their performance in the lab. And that's one of the things that's very hard, and something I'm not that comfortable with yet.

Similarly, Richard has difficulty with:

how to make a test that reflects program goals, is closer to the spirit of the program.

That's another thing that's beyond me. I've sat and thought for hours: what can I ask that will be a legitimate test of these things? The answers I come up with still aren't right, and it requires more time than I'm really willing or capable of putting in to evaluate honestly. It almost amounts to personally interviewing each kid, and observing them more closely in class than I'm able to.

We see that evaluation for a constructivist curriculum with diverse program emphases perplexes our two teachers. Of course they are not alone in this, as the STS literature indicates. Hofstein and co-authors (1988), for example, report that "the general feeling among the STS Working Group (*at an international symposium*) was that evaluation and assessment is particularly difficult due to lack of valid and reliable evaluation tools" (p. 364). But is this, in reality, the root of the difficulty for Richard and Susan?

For part of the answer to this question, we need to once again return to the two sets of world views at the centre of this work. On one hand we have been speaking of positivism and its many ramifications, such as banking education (Freire, 1989). Banking education closely corresponds to what Barnes (1975) calls the *transmission* view of teaching and learning. If knowledge exists "in the form of public disciplines which include content and criteria of performance," then the task of the teacher is "transmit that knowledge and test whether the pupils have received it," by "the evaluation and correction of of the learner's performance" (Barnes, 1975, p. 144).

This describes the conventional type of evaluation for junior high science, based on the "acquisition of knowledge," with which Richard and Susan are well-acquainted.

Alternatively, Barnes talks of the *interpretation* view of teaching and learning. Here, knowledge resides in "the knower's ability to reinterpret knowledge and reality for himself," so that the teacher's task is "the setting up of a dialogue in which the learner can reshape his knowledge through interaction with others" (1975, pp. 142-144). In essence, Barnes' interpretation view encapsulates a postpositivist framework of ideas which we have previously touched upon, as an interpretive orientation to research, as constructivist psychology, and as dialogic education. A particularly important distinction to notice is that while the transmission mode of education can easily accommodate an unproblematic and unidirectional flow of knowledge and evaluation, an interpretation perspective can not. What we are faced with is something that, although it may be encountered in other school disciplines (Barnes, 1975), is not at all routine for science education: *evaluation as dialogue*. In testing for knowledge and comprehension with multiple-choice or short answer questions, for instance, there is little or no element of dialogue; this is the realm of the right answer. Evaluation that is cognizant of the possibility of right answers would have to assume a different form; and this would seem to be where Richard and Susan are adrift.

To "formulate an evaluation that's fair," or "make a test that reflects the program goals," would require a conception of evaluation in terms of continuous dialogue between students and teachers. What forms might such evaluation take? Barnes (1975) suggests that "interpretation" teachers view written work as part of a dialogue in which students play an active part, and as a means by which students reshape their view of the world and their ability to think about it. Interpretation teachers, according to Barnes, write replies as well as comments on student work, and use it to influence

the direction of future lessons. For measuring student achievement in junior high science, Mrazek (1989) recommends such techniques as involving students in establishing criteria for evaluation, discussing outlines for tests with students, interviewing students, and student self-assessment, all of which contain an element of dialogue. These few examples suffice to make the point that the difficulties of evaluating in an science course based on constructivism, and the discomfort experienced by Richard and Susan, are not to be resolved by the mere modification of existing testing methods, but by placing evaluation on a different footing altogether.

It seems that the implications of science education as dialogue stretch beyond technique, to freedom. Granted that the program emphases in the Alberta Junior High Science Program call for new methods of evaluating skills and attitudes, as well as the conceptual knowledge we have been discussing. But the radical import of the constructivist ideas underlying the program is that they imply a movement towards a different mode of being for junior high science teachers, of which evaluation is but one facet. I am suggesting that dialogic evaluation as outlined above is consistent with notions of positive freedom, such as having choices in thought and action, and becoming more fully conscious and human. On freedom in education, Dewey writes, "freedom means essentially the part played by thinking..in education: it means intellectual initiative, independence of observation, judicious intervention, foresight of consequences, and ingenuity of adaptations to them" (1916/1966, p. 302). The sort of education based on classroom dialogue, which Freire (1989) calls "education for the practice of freedom," would find students playing an active role in the shaping and re-shaping of knowledge, participating fully, and interacting freely with others in the classroom, and would find a teacher surrendering at least some initiative, power, and control over evaluation and other curricular matters to pupils.

But will the technological society allow such freedom for students and teachers? Although attempts to deny freedom in such areas of thought as philosophy, science, and mathematics have largely failed (Barrett, 1979), the flight from freedom through the productive apparatus, and the subjugation of institutions to corporate economic structures continues apace. As we have already seen, scientific management techniques, and attempts to control schools and curriculum through top-down curriculum development strategies are widespread in North America. In the school district in Alberta where Richard and Susan teach, there seemed to be no overt attempt during the first year of the junior high science program to control the curriculum :

Q: What about professional evaluation? Do principals or superintendents evaluate grade 7 science teachers in this district?

Richard: No, they never evaluated the course, only the teaching, and nobody has ever evaluated my science courses, other than how my kids did on the achievement test (for the previous program).

However, there are apparently plans afoot at the district administration office to implement an annual achievement test for the new grade 7 program. Richard and I talk about his present freedom to make curriculum choices, and the likely effects of a standardized achievement test on that freedom:

Q: Can the spirit of the program be reached by going into more depth?

Richard: Yes...I could knock off a few units now that I've taught the course, even get it down to one unit, because every unit is full of places you can go where the kids are interested.

Q: But not everyone agrees with this, and your district is talking about an achievement test for grade 7. What is that going to do?

Richard: It will pull it back to the previous philosophy, a whole lot. Like, you start teaching towards the test, which is just a collection of memorized things—155 multiple choice content-based questions. My students are going to write it this year. They're (*administrators*) just missing the point, somebody just hasn't read the goals

of the program. As long as Alberta Education has a grade 9 achievement exam they are going to continue: "we have to get the kids prepared for when that one hits."

Richard's professional autonomy is directly related to his pupils' freedom to learn. Recall that the spirit of the program, as described in the program rationale (see earlier, p.44), is captured by such phrases as "attention is given to the processes by which scientific knowledge is gathered, largely by involving students directly in the practice of scientific inquiry, and "the processes of problem-solving and decision-making are given direct attention in learning activities: students are involved in ways that stimulate their critical and creative thinking skills" (Alberta Education, 1989, p.1). By going into more depth on fewer units, Richard feels he can follow his pupils' interests in a shared journey towards knowledge, involving pupils in inquiry, problem-solving, critical and creative thinking: "every unit is full of places you can go where the kids are interested." He realizes that, as Dewey (1916/1966), Holt (1967), Rogers (1983), and others have emphasized, real learning only occurs under conditions of freedom. "What is essential is to realize that children learn independently...; that they learn out of interest and curiosity, not to please or appease the adults in power; and that they ought to be in control of their own learning, deciding for themselves what they want to learn and how they want to learn it" (Holt, 1967, p.153). It is clear that only when a teacher has freedom of choice over curriculum—the freedom to engage students in a fluid dialogue about their shared world—can students themselves have the necessary freedom to "learn out of curiosity and interest."

What Richard is telling us about above is yet another instance of lived contradiction between technical rationality and a post-positivist world view—between unfreedom and freedom. The district achievement test arises from the technical logic of scientific management, which decrees that all Alberta grade 9 students shall write a standardized science achievement test, in the interests of uniformity, accountability, and

standardization. Following the same logic—fleeing the insecurities and anxieties of freedom—district administrators decide that grade 7 students must be prepared for the grade 9 achievement test, lest their students be found non-uniform, and themselves accountable. But we see that such control by testing is incompatible with curriculum freedom: "it will pull it back to the previous philosophy, a whole lot." Control means a 155 question multiple-choice content-based test, which Richard feels would leave no choice, except "teaching towards the test." The point that escapes the administrators is that management techniques such as standardized testing are not neutral, but embody a philosophy quite antithetical to the new program goals of junior high science.

Susan too, has concerns about district achievement testing in grade 7 science:

Q: You said at one point, that next year you would water things down and cut back to make it fit.

Susan: Watering it down? Yes I have to cut back, because there is the pressure, and the threat of a district exam. I don't know how they're (*administrators*) going to do it. If the students don't perform you look at the teacher, not the kids.

"Watering it down," and "cutting back to make it fit" are interesting curriculum metaphors. Susan is articulating the sense that technical curriculum development strategies create a standard container of precise measurements, into which the unwieldy bulk of student freedom must be crammed, or alternately, in which the concentrated essence of children's meanings must be diluted to bring them to standard strength. Like Richard, she has spent much more time than recommended on some units following student interest and doing a variety of learning activities, but the pressure of an achievement test will likely force her and her pupils into the standard mold envisioned by her superiors. When Susan says, "I don't know how they're going to do it," she shows she is also sceptical about the possibility of a standardized multiple choice examination

capturing the spirit of the program—confounded by the dissonance between the two philosophies involved. And, as she reminds us, "if the students don't perform, you look at the teacher, not the kids." The examination is as much about the control of teachers, as it is about control of students or subject matter.

If we shift our attention from Richard and Susan back to the larger society, we encounter similar findings relating standardized testing to loss of freedom in classroom life. In recent studies of the effects of provincial diploma examinations on science teaching and learning, both Samiroden (1990), and Wideen et al. (1990) report that this type of examination plays a strong role in directing grade 12 teachers towards a more didactic style of teaching, involving more lecturing, testing, and reviewing of examinable content, but less laboratory work, projects, and other activities. Wideen et al. found that in grades 8 and 10 in British Columbia schools, where there were no external examinations, patterns of science teaching differed widely from those in grade 12. While standardized testing "is a quick and efficient means to get some measures that enable cross-group and cross-community comparisons" (Cheek, 1992, p. 1), there seems to be a gross mismatch between typical goals for science education in North America today and most available tests. But even if more valid assessment instruments, such as improved multiple choice tests, open-ended essay tests, or performance-based measures of skills and understanding were developed (Cheek, 1992), the question remains whether large-scale testing of any kind is conducive to learning in the classroom, or even if it is necessary at all (Perrone, 1992).

Given one particular philosophical framework, large-scale testing and other overt attempts to control teachers make perfect sense, and only need to be made more precise and efficient to work well. Approaching the matter with another set of assumptions, we see standardized testing as part of a larger enterprise of societal

control. Teacher autonomy and teacher empowerment are largely issues in the light of attempts to define education in terms of the "logic of the marketplace" (Giroux, 1988), and to align education more closely with the needs of the corporate economy. In Canada, this process now seems less advanced than in the United States, where policies such as standardized curricula, increased testing, and competency-based testing for teachers are more evident (Apple, 1982, 1986; Giroux, 1988). However, neo-conservative policies consistent with those of the U.S. and U.K. are very much alive in the agenda of governments in Canada today.

The problem of freedom penetrates life in all aspects in this country. On one level there is tremendous public debate, both provincially and federally, about the adequacy of our current democracy. Does our society "make provision for participation in its good by all its members on equal terms" (Dewey, 1916/1966, p.99), or is it rather an instrument of corporate elites? Are schools and classrooms sites of free choice, autonomy, and authentic learning, or subject to manipulation for economic ends? Dewey stressed that freedom for teachers, for students, and for society are essentially one and the same. A democracy that is free, open and just, must be devoted to a kind of school life that can educate its citizens for freedom, personal initiative, autonomy, and a sense of shared community. This is possible only when teachers retain their professional autonomy, and free choice in thought and conduct.

But what are the implications of "freedom to" for the actual subject matter of a science curriculum? What does it mean for teachers and students to meet the world in its plurality, uncertainty, and freedom?

Teachers' Thoughts on an STS Curriculum

"The Right Stuff"

While our eyes and ears receive impressions only in humanly manageable proportions, our concept of the world has lost that quality; it does not any longer correspond to our human dimensions. (Fromm, 1955, p. 110)

What Fromm is dealing with here is the relationship between people and their world. In our advanced industrial civilization, he argues, the trend in scientific thought, as well as economic and social thought, has been to "an almost exclusive reference to the abstract qualities of things and people, and to a neglect of relating oneself to their concreteness and uniqueness" (p. 106). This trend towards the abstract and the quantified in knowledge thus alienates modern people from their personal lived concrete worlds.

When we are speaking of young people in classrooms and science curriculum, this is clearly a concern. For example, Richard relates that his experience of science curriculum, as learner and as teacher "has always been a question of knowledge, not knowing; science has never seemed anything other than 'do this experiment and get these results', or, 'memorize this for the next exam'." Typical science courses which overemphasize content such as those experienced by Richard concentrate on scientific knowledge that is abstract, public, and generalized. Of course, as Franklin (1989) puts it, "it is the strength of the scientific method that it provides a way to derive the general from the particular, and then in turn allows general rules and laws to be applied to particular questions" (p. 38). But that very separation of knowledge and experience which is such a powerful tool in the hands of scientists and engineers, can also distance scientific knowledge from students' own lived experience, and hinder genuine learning. We have already seen that constructivist psychology conceives learning as the

reconstruction of experience, and that knowing—thinking, reflecting, interpreting, and understanding—consists of the processes that connect experience with knowledge. Is it possible for science curriculum to re-connect students' experience with scientific knowledge, and allow a different relationship between learners and their world?

It became evident in our conversations that Richard and Susan felt that the new junior high science curriculum was, in a number of ways, "the right stuff" for their students. For one thing Susan thinks the program is more appropriate for her students:

I've seen some people who've done a really heavy job on 7 science, where they had notes and content that was so incredible, and all the kids did was memorize. Well, they're only twelve years old, they're still children. They don't need that kind of background, to know all the phylums and kingdoms and everything—that's useless! The stuff they're doing right now is much more hands-on, much more appropriate..

Q: You think this is better material for the kids?

S: It's more appropriate age-wise, more appropriate subject-wise. I'm an advocate of the new program. The old program—as far as I could see it didn't meet the needs of the kids. To me that's important—you have to look at where the kids are coming from, and where they're going, and you don't give them high school biology at a grade 7 level.

The new curriculum and accompanying textual materials seem to be much better suited to 12-13 year olds: more concrete and "hands-on." Susan is aware of her students' limitations as far as abstract thinking goes, and the need for activities in which they can learn by manipulating concrete objects. The new subject matter is also more appropriate in that it bears a closer relationship to students' lived experience—the topics and materials are more related to their own world and existing knowledge. The curriculum attends to not only "where they are coming from," but also "where they are going." That is, very few of Susan's students will likely become scientists or technologists, but all will become citizens of a highly scientific and technological future society.

Although science itself is highly specialized, and scientists seem to operate in increasingly fragmented disciplines, young people experience the world more as an integrated whole than along the lines of discipline boundaries. Grade 7 students simply do not perceive the world in the same way as professionally trained biologists. Susan seems to appreciate this, and is strongly disposed towards an interdisciplinary approach for junior high science:

I'm very pleased with the new curriculum. I think that the mistake that was made (*with the old curriculum*) was they had biology in grade 7 and a lot of them got turned off, because all they did was biology, biology, biology! Then they didn't have it again for two years. This way they get a little bit of it, then something else, and I think that it gives them a break, and yet keeps their interest, because it's very diverse. And it shows them that science isn't simply one component, but many components.

"Keeping their interest," as we have already seen, is a fundamental concern for Susan. Yet it is not only the diversity of the subject matter, and the changing focus of attention in the program that maintains the pupils' interest. An interdisciplinary organization of subject matter is conducive to curriculum planners' drawing away from the abstract and generalized knowledge of the established scientific specializations, towards the concrete and familiar. Instead of the logical, systematic structure of an academic discipline, alternate organizing principles, such as the everyday lifeworld of the students, or interesting phenomena, can be utilized. This makes it possible for students to, as Fromm puts it, "relate the self to the concreteness and uniqueness of things," and re-establish ties with a world of "human dimensions," and ultimately make sense of their lived world in new ways. But will all students be able to do this?

The STS slogan "science for all," implies that previous kinds of science curricula had been "science for some." In fact, the secondary science curricula of the 1960's were specifically designed to increase the number of scientists and engineers: a relatively small, elite, and mostly male group. But in the 1980's and 1990's, many

countries, faced with rising societal expectations for schooling, higher unemployment, and the need for a more highly educated workforce, have shifted the focus of secondary schooling from elite education to mass education, and science education for all (Fensham, 1988). The feminist movement has also had an impact on perceptions of whom science education is for, drawing attention to the low participation of females in school science and science-related professions, and to male gender biases in science, science curriculum, and science teaching (Benston, 1982; Sjøberg & Imsen, 1988; Kahle, 1988). The Science Council of Canada (1984) recommended that new science curricula being developed in this country increase the participation of young females in science education. Has the Alberta Junior High Science Program moved the science classroom in this direction?

Susan seems to think so:

Q: One of the things STS education is supposed to be is "science for all"—all abilities, males and females, and so on. Have you seen that happening?

S: The girls love it. And just getting the girls involved—in that first experience, of the kids' building (the tallest free-standing paper structure), in one class boys won, and in the other class girls won. And the boys thought that this was really something..But when you're looking at boys and girls, and the encouragement for both to get involved, it definitely approaches that.

Girls' enjoyment of and involvement in the subject matter and activities was noticeable in both Susan's and Richard's classes. What is behind the "encouragement to get involved" in this curriculum? Research on gender in science education reveals consistent patterns of adolescent boy-girl differences: girls are more interested when curriculum has personal relevance to them, when it is related to everyday life or society, or when the subject matter has aesthetic or ethical dimensions (Sjøberg & Imsen, 1988). We saw an instance of the latter trend in Susan's class when students had the

task of making a structure from straws, paper clips, string, glue, etc. Here is an excerpt from my field notes:

The 10 groups are at various stages of completion. One group of boys has all but completed a simple pyramid structure. Another trio of boys is nearing completion on an elaborate construction of linked pyramids, by far the most symmetrical, impressive structure...The girls—four groups or so—seem to take a slightly different approach. They don't want to try for tallest or strongest structure, but most creative or interesting. One group of girls started with a pyramid, then added a square frame above it, and then got into decorating it with hanging pyramids... Another group of young ladies started with sort of a pyramid, which then evolved into a house with straw people in it and a sign above the doorway. It was as if the girls were oriented to this as an artistic exercise, and their trial and error additions had more the flavor of an artist developing a piece, than an engineer building a model.

Susan also notices other gender differences:

Q: One of the things that we were discussing in the senior high science committee was "what's in this for the female student?"; and there were a few women there who were saying "you've got to make it relevant and interesting to girls."

S: Well, I think that the kids are challenged, and with different components, there are different interests. With the male-female thing, in grade 7 I don't see a great differentiation.

Q: Well, I noticed a few days ago, with the skateboard example...

S: The boys all answered, and the girls didn't.

Q: That really got the boys interested, and there was just the one girl who had anything to say about skateboards. This unit ["Structures and Design"] as a whole, is it a more boy-oriented?

S: It's more male-oriented, and "Living Things" is more female-oriented, if you want to look at it that way. You'll get more girls discussing things in that component. I don't see anything wrong with that. 'Cause you're not going to have an even thing—a lot of boys tend to build, and girls don't. You're going back to the way they are treated at home. I think the fact that they both have the chance to do it in the lab and to play, that to me, is where it's at. Some the kids have never had the experience—a chance to do it, and there may be an interest there that they weren't aware of, because it hasn't been cultivated at home.

What we observed in Susan's classes appears to be a not uncommon male-female differentiation among students (Sjøberg & Imsen, 1988): boys more interested in things technological and mechanical (cars, skateboards, using tools, electricity), and girls more interested in biology, the human body and health. Susan's perception about the origin of these differences—"the way they are treated at home"—is also consistent with research findings that examined patterns of experience in boys and girls in Norway (Sjøberg & Imsen, 1988). Not surprisingly, girls' experience tended to center around home, household, and garden, while boys' experiences focused on using tools, fixing things, motors and the like. If we assume, as Susan does, that such differences are cultural, rather than biologically determined, the same basic curriculum principle is evident. Students will become involved in science subject matter that is related to their particular and unique lived experiences. Susan sees that the junior high science program successfully engages both boys and girls by including subject matter which would likely appeal to each gender. Moreover, by including varied subject matter, the program acts as a leveller of experience, by "giving both (*boys and girls*) a chance to do things in the lab."

What Susan's experience of the program points to, is the importance of finding a *human context* for science education. By this, I mean turning to the lived world of qualities: a more intimate world of human senses, shared personal experience, relationships, feelings, right and wrong, and beauty. On the other hand, the traditional (and incorrect) concept of science fostered by many curricula, textbooks, and teachers, as cold, logical, impersonal, and objective (Sjøberg & Imsen, 1988; Kahle, 1988) is what turns girls, as well as many boys, away from the subject, because it denies the worlds in which *they* live.

Diversity is a dominant feature of both the natural and the social worlds. Any science class, for instance, especially in a non-elitist unstreamed system, will show many differences other than those of gender, such as differing cultural backgrounds, personalities, learning styles, levels of cognitive development, and so on. How does the new Alberta junior high curriculum address these differences? Is this the right stuff for everyone? Here is what Susan has to say about it:

Q: With students of different abilities and so on, I was noticing the one boy, Bobby, who seemed quite interested today [*he usually had appeared to be inattentive*], and seemed to be coming up with some good ideas, for instance, putting the container 15 cm away above the cup. Most of them stuck to what was in the book, but he got on to it right away. I have seen this elsewhere, that this unit can level out academic abilities. Have you noticed anything like that?

S: You see such a different range when you get into this sort of thing (*the new curriculum*). You'll see the kids that aren't that academically strong when it comes to writing skills, but are very creative. Or, you'll see kids that can take an idea and really modify it, but if you put them into a structured situation, they just don't cope at all. I see different things depending on the activity—it meets the needs of kids at different levels.

There is an implicit assumption here on Susan's part, that diverse abilities exist within a classroom. In the context of a content-driven course, emphasizing memorization, written work, and knowledge questions, academic ability may come to be very narrowly defined. But we have here a science curriculum which apparently promotes a wider range of thinking, skills, and abilities, and therefore implies plural definitions of academic strength and weakness. With a broad range of goals being addressed, it makes less sense to talk of weak students and strong students, because a teacher will "see different things depending on the activity." As an example of this, Susan refers to the way the straw-building activity described earlier seems to address a particular learning style:

This final activity, I'm sure that it's one of the best activities there. I like to build it up, because they do look forward too it, and when they do get to it they are really into it. The children who are very tactile-oriented are the ones that concentrate on it the most. The children who seemed to be more abstract, or auditory, or visual learners are the ones that didn't apply themselves so well.

Regardless of the validity of the notion of fixed learning styles among students (tactile, auditory, visual), Susan recognizes that for this particular activity and these particular students there are diverse approaches and abilities, and on this day, students have a chance to excel who may not on other occasions.

Meanwhile, in Richard's classes, similar observations could be made. The students had completed the task of spanning a book "canyon" with a bridge constructed of cardboard, masking tape, string, paper, and glue. I observe in my fieldnotes that:

The bridges from the two classes are varied; from sophisticated and elegant, to crude, ineffective, and ugly. They have used a variety of designs from the bridge handout. Some girders, strings, etc., do something, but many don't and just dangle uselessly. Some are sturdy, others are laughably flimsy—the full range in each class. But actually the very worst ones are from 7Y, the more "academically-inclined class."

Here, "academically successful" children produce truly haphazard and hazardous cardboard bridges, in contrast to masterful examples completed by some of their "lower-achieving" peers. And again, a constricted definition of ability seems unable to accommodate strong memorizing and test-taking skills on one hand, and teamwork, design skills, and manual dexterity on the other, especially when one considers the types of skills in demand for the modern work-place.

Thinking skills are also getting more emphasis in education today, including in the Alberta junior high program. There is a concern with what students can *do* with their knowledge, with their ability to think. Richard and I discuss how the program generates thinking about content in his two classes:

Q: I was watching them (the 7Y class) today, trying to to get an idea of how engaged they were in the activity you were doing about the uses of objects. I don't think there were any who weren't engaged a large part of the time. Even the kids at the front desk, they were like this (researcher demonstrates: hand straight up, look of rapt attention). I wouldn't have thought that it would engage that group so much (R: Nor would I!)—"what can we use a glass rod for?" Once they got into it, they really started to think.

R: I was a little hesitant to...I didn't think it would work, I had another thing to do if it didn't. It went really, really well, in my block 2 (the "more academic class"), so I'll give it a shot and see what happens, and it went really well.

Q: Was there any difference in the number of ideas?

R: Oh, there were far more ideas, a wider range of ideas, in the afternoon, and firing at me, with no prying at all. Once they get into something, they certainly get into it.

Once more we see opportunities for success for a broad spectrum of students in Richard's classes. Of course, it would be a mistake to attribute too much to the syllabus, and not acknowledge that Richard and Susan's excellence as teachers has much to do with the kind of classroom experiences described above. But by their own accounts, such events are much more frequent now than with the old program. The above account of 7Y's rapt attention, and the quality (and quantity) of their thinking suggests that when curriculum is placed in a context of the concrete and familiar, rather than the abstract and arcane, more students are able to participate, and even excel. Are our usual notions of "academic ability" merely artifacts of inappropriate curriculum?

Then, on the other hand, what is "appropriate curriculum"? An alternate meaning of appropriate is "to make one's own." If we consider this phrase, there is a sense of ownership here, but more than that, a sense of close relationship. Now it is the matter of how curriculum shapes students' relationships with their world that we have been examining. Science as a question of knowing, "appropriate science" for young people, is a question of connectedness between knowledge and experience.

Another way of looking at this connectedness is to call it "relevance" (Webster's: a close logical relationship to the matter under consideration). So, for a junior high science curriculum, exactly what is the logic of relevance?

Here is Richard on relevance:

Q: What about relevance? Is this (the "Structures and Design" unit) the right thing for kids to be learning?

R: Relevance is an interesting thing. If you want to define relevance in terms of, what practical use will a grade 7 kid have for knowledge of building bridges, then it's irrelevant. If you want to define relevance as "are these kids interested in this topic?", then, yeah, it's incredibly relevant. Memorizing the parts of a cell is probably a pretty relevant exercise given that we are all composed of cells, but it's totally irrelevant to grade 7's, because they're just plain not interested.

That's how I define relevance, and I'm sure every dictionary on earth would disagree with me. The factual content is really irrelevant in this whole issue anyway, what's relevant is what they're learning in terms of applying knowledge—the content is just a vehicle.

Susan too recognizes where relevance lies for her pupils:

The world of the junior high student revolves around themselves and today (not tomorrow or yesterday). That's where you've got to start to be effective. You look at the age of the child and where they're functioning in order to make something that will be effective and they will buy into. So it's got to be the needs of the kids first.

Various logics of relevance are encountered in curriculum discourse. Richard clearly identifies three definitions of relevance, which can be linked to the curriculum orientations discussed in an earlier chapter. First, there is a utilitarian definition, the logic of direct usefulness in everyday life or workplace: "what practical use will a grade 7 kid have for knowledge of building bridges." Second, there is an academic definition of relevance, the logic of preparation for subsequent courses, and of understanding the world the way an adult scientist might: "memorizing the parts of a cell...given that we are all composed of cells." And finally there is a pedagogic

definition, the logic of student learning, growth, and development: "are kids interested in this topic?"

In Richard's and in Susan's view, the latter definition of relevance receives the greatest emphasis in the Alberta junior high science program. This accounts for it being "the right stuff" for their students; "something that will be effective and they will buy into," as Susan says. It is the logic of starting with the lived world of the student, which "revolves around themselves and today," and with their particular needs and characteristics...the age of the child and where they're functioning." Of course, other notions of relevance are embedded in the program as well, such social relevance (the logic of curriculum linkages with social trends or issues), utilitarian relevance, and academic relevance. But it is a logic of relevance which necessarily connects curriculum, not to societal crises, nor economic imperatives, nor post-secondary requirements, but to learning, growth, and development of young adolescents, that our two teachers see as most appropriate. They rejoice that, as Richard put it, "finally someone had paid some attention to kids when developing a curriculum."

Is it possible then, for science curriculum to establish a different relationship between learners and their world, to reduce the distance between lived experience and science? With the new Alberta junior high science curriculum, we have seen that more of Susan and Richard's students are able to participate in science: students of both genders, students of diverse abilities and interests. This seems to be made possible by a closer relationship between subject matter and the students' own lived world. Since students are not all the same, the program addresses student diversity by providing points of contact between students and subject matter with a variety of topics and approaches. The basic principle is clear—when science curriculum draws away from the abstract towards a human context of concrete and familiar aspects of everyday

experience, for students, science can become a matter of knowing, not merely of knowledge. Having discussed the necessity of a human context for knowledge, we next consider how a similar principle holds true for the larger enterprise of curriculum development and for the teacher's role within it.

Implementation Re-Viewed: "Making it Right"

If we look more closely at the word "implementation," a revealing interplay of meaning comes to light. The verb "implement," from which implementation is derived, means "putting a plan into effect," but the noun "implement" means "any person or thing used as a means to an end; a tool or instrument" (Webster's New World Dictionary). Therefore embedded in the word itself is the concept of instrumentality: using persons as a means to an end. This brings us in touch once more with that feature of modern life which Fromm (1955) calls "abstractification." In a society in which economic activity is the main preoccupation, abstractification, an overemphasis on the abstract qualities of things, has moved beyond manufactured goods to include people as well. This tendency towards the abstract manifests itself in two related social phenomena, bureaucracy and a marked division of labor (Fromm, 1955), both of which entail a conception of people as machine-like objects, or tools to be manipulated as means to economic ends. Curriculum implementation, conceived as "putting curriculum plans into effect," is rooted in a "production metaphor," implying that teachers are impersonal cogs in a larger curriculum machine, whose purpose is to efficiently transmit knowledge to students. What this scheme misses entirely is any real point of reference to autonomy, morality, or other key dimensions of a *human context* for education. Autonomy for teachers and students is either irrelevant or counterproductive to the achievement of the ends of the productive system, while right and wrong are subservient to the market, which provides its own definitions of "the

good" for students. Yet it is within these two realms that the technical notion of curriculum implementation errs most seriously.

In chapter 2, the practical and intellectual shortcomings of the production metaphor and its associated model of curriculum implementation were argued. An alternative view of implementation was suggested that conceives teaching as *practical action*, that is, as a form of human interaction in which teachers' deliberate about what is right for students in concrete situations. Teaching as practical action implies autonomy and freedom of choice, for wise decision-making is based on the particularities of the classroom situation, not on external purposes. And because teaching involves adults in a position of power over young people, teaching as practical action is also inherently moral, oriented not to the requirements of the marketplace, but to individual pupils' growth, development and learning. Susan and Richard's talk of what it means to them to implement an STS curriculum exemplifies the notion of "teaching as practical action."

Here is Susan:

Q: What does implementation of a new curriculum mean to you?

S: It means carrying out the curriculum the way it specifies to the best of your abilities, but it also means meeting the needs of the students...

Q: If it comes down to what the curriculum spells out, or the kids needs, which one do you give precedence to?

S: The kids' needs, because if you're not meeting their needs, you're not doing your job. The curriculum is there as a guide, and you do the best you can with it, but you've got to address the needs of the kids and look at where they're coming from... You've got to go with them, otherwise it's an act of futility, and they'll turn off... I know what the guidelines are for, but you have to blend the two (*curriculum and needs of kids*).

Susan shows that she is no mere functionary in her "implementation" of a curriculum. It is not a matter of faithful translation of curriculum plan into classroom action; nor of

careful local modification of the blueprints to get them to work. She does not see her role as the passive transmission of others' ideas, or the efficient use of teaching skills to carry out predetermined ends. Hers is a balancing act, attending to both curriculum guidelines and the here-and-now needs of her students. But in the everyday reality of a classroom with 30 students, priority number one for Susan is meeting their needs.

Richard has a similar conception of implementation:

Q: What's the teacher's role in making science curriculum work?

R: The teacher has the toughest job. The curriculum has to be adapted to the group you are working with. The teacher must be on top of what the curriculum planners have suggested, guided by what he feels the class requires, and mesh them together somehow—it's not easy! The teacher's job is adapting one thing to another, honest to the intentions of the curriculum, and the needs of the kids.

R: Needs of the kids?

A: Their learning styles and characteristics, what their academic strengths and weaknesses are, like thinking skills, memorization, work habits, organization. Every kid has a bagful of needs: to develop a store of facts, process skills, basic social skills. Another thing is tending to their personal needs—why some kid is crying. You are teaching science but you are also teaching kids.

Q: Do the two kinds of needs conflict?

A: Not usually. Sometimes kids personal needs take precedence over academics. The dilemma is, at what point do you slow down to address the personal needs of 25-30 kids? You are always sacrificing one thing for the sake of the other.

Compare Richard's phrase to Susan's: "meshing them together" (curriculum and kids' needs), versus "blend the two." There is a sense in these words of attempting to knit or fuse together opposing or disparate elements not easily joined; of attempting to resolve contradictions in the classroom between the academic and the personal, between the intentions of the curriculum and the needs of their pupils. I would argue that such contradictions originate in conflicts between the legacy of positivism and other modes of thought in our society. For example, the metaphor of technical rationality—

production—applied to science education gives us centralized curriculum planning, learner expectations, curriculum guidelines, and quality control measures such as standardized examinations.

But Richard and Susan, like many teachers, are animated instead by a growth metaphor, oriented to students' growth and development, and are faced with the difficult task of reconciling "growth" with "production." When Susan and Richard speak of "needs," they are not speaking of needs as defined by distant experts in accordance with the requirements of the market economy. The "kids needs" they talk about are related to what is required for their particular students to learn and grow, such as positive learning experiences, appropriate knowledge and skills, as well as basic human needs like nurturing, and even, as we have already seen, fun, enjoyment, and interest. Richard, for instance, reveals that in the microbes and food unit,

we did a lot of activities (from the textbook), but I adjusted almost every one to make them more interesting. In the collecting microbes activity, I made it more of an experimental design, comparing things like a toilet seat before and after disinfection. It was the strongest set of labs (reports) of the year. I was very pleased. The fermentation lab, the one with the balloons, we added grape juice and potato juice, trying to make wine and vodka. The kids really enjoyed it. (*the activity, we presume*)

No doubt many successful teachers like Richard and Susan modify or devise learning activities to make them more interesting and enjoyable for their students. However, this is not because they are accountable to the department of education for measurable fun and enjoyment, but because they are oriented to what is needed for genuine learning, and to the human quality of classroom life.

The technical rationality embodied in the notion of "curriculum implementation" is also in conflict with the constructivist thrust of the junior high science program. Here I ask Richard if faithful implementation is possible for the program:

I don't think the spirit of the new program is in a "faithful representation." It represents science as it is, rather than as a body of facts. I could present a more "technically accurate" version and miss the point of the curriculum. My understanding is that the curriculum is aimed at the process skills, rather than developing a body of knowledge.

The point of the curriculum, as Richard suggests, is not science just as an inert body of facts, but science as process skills which generate a more personal reconstruction of knowledge; science as a more authentic human relationship between learners and their natural world. If, as the document itself proclaims, the curriculum is aimed at students "reflecting upon their experiences," "discovering and constructing meaning," "understanding and interpreting the world in which they live," then an accurate copy from plan to execution as from blueprint to machine is clearly not possible. Given the indeterminacy of learning, and the diversity of students and teachers, the inevitable result is not a list of facts learned with a close correspondence to the curriculum guide. The result will be, within limits, a pluralism of knowledge among students and teachers, and somewhat ambiguous, and difficult to measure process skills. The production model of education, and the "fidelity concept of implementation," admits neither the complexities and uncertainties of classroom life, the ambiguities of a constructivist curriculum, nor what teachers are trying to do in the classroom.

As we can discern from Susan and Richard's comments, "implementation" is no simple matter of putting change into practice. Rather, for them implementation means a complex resolution of opposing forces in the classroom; caught between a felt responsibility to curriculum mandates and a commitment to the pedagogic good, but fundamentally and necessarily oriented to the latter. I referred earlier in this work to Stake and Easley's observation that "the problem (of curriculum implementation) is less one of willingness than of contradictory purposes" (1978). Teachers such as Susan

and Richard trying to implement an externally planned curriculum are faced with such contradictory purposes: quality control in the interests of uniformity on the part of the curriculum planners, and attending to the learning needs of students on the part of teachers. What Richard and Susan are engaged in is practical action, not efficient execution of plans made elsewhere. Teaching as practice, rather than technique, means constant deliberation regarding the "right action" for furthering personal growth and learning of the children for whom one is responsible. It means taking a curriculum innovation and "making it right" for your students: somehow reconciling the larger impersonal world of public knowledge and public policy, with students' own lived world of human dimensions.

Summary

This chapter has presented an interpretation and analysis of two teachers' lived experience of curriculum change from a program which promoted rote memorization of content to a more activity-based and constructivist-oriented science-technology-society course. Susan and Richard are two experienced, successful, and caring junior high teachers, with a strong commitment to students' growth and learning, and a common belief in learning as process: understanding and applying knowledge. We saw that the new program "feels right" for Richard and Susan because, although there was some discomfort with the transition, they found more pedagogical satisfaction in a program that promotes a more social, authentic kind of learning; learning marked by interest, enthusiasm and enjoyment. The new curriculum also provided more "right answers," which meant not only more freedom of choice, but also greater ambiguity and uncertainty. It was argued that the STS program introduced several lived contradictions into the classroom; in essence the clashing implications of positivist and postpositivist ideas embedded in curriculum and practice. But the new curriculum seemed to be the

CHAPTER 6

Conclusions

In this, the final chapter, I would like to reflect upon the study as a whole, in an attempt to evaluate and situate the work relative to the larger body of curriculum discourse. By first summarizing significant aspects of the context, questions, theoretical framework, methodology and major findings, I endeavor to provide an overview of the study. This is followed by a discussion in which the study's findings are re-evaluated in light of issues raised by the theoretical framework (chapter 1), the literature review (chapter 2), and the analysis of the Alberta Junior High Science curriculum (chapter 3). The findings are then evaluated in terms of comparable research in the literature, and the validity, limitations, and possible weaknesses of the study are explored. The chapter closes with a consideration of the implications of the study for curriculum theory and practice.

Overview of the Study

There seems to be general agreement that modern industrialized society in the late twentieth century is beset with a myriad of social, political, economic, and environmental crises. At the same time, North American schools are perceived to be both part of the problem and part of the solution, and therefore facing increasing demands and criticisms from a variety of quarters. The school curriculum has widely been seen as unresponsive to the rapid changes occurring in knowledge, the environment, the workplace, and society in general. Recently, the science-technology-society (STS) curriculum movement has been the focus of a major rethinking of the goals of science education in many nations, away from traditional courses based on the structure of the scientific disciplines, towards interdisciplinary courses emphasizing scientific literacy for informed citizenship, and a return to personal goals for science

education. The province of Alberta was among the first in Canada to make such a program mandatory for all junior high school students, when it introduced a new STS-oriented program to grade 7 students in 1990.

The present study arose from the interaction of the latter event with issues in the field of curriculum studies. Attention has often been drawn to the need for curriculum theory and policy to be grounded and informed by the lived experience of teachers in classrooms. In particular, the lack of success of science curriculum reforms in schools over the past several decades has pointed to the need for classroom-based research on STS curriculum initiatives, in order to foster a better understanding of the interactions of STS subject matter, teachers, and students in schools. Accordingly, the study addresses the question, "how do teachers experience a new STS curriculum in their everyday working lives?" The question also implies a reconceptualization of the idea of "implementation" and current curriculum development practice in general, as well as a critical analysis of the Alberta Junior High Science syllabus in terms of its social, political and curriculum contexts.

The theoretical premises of the study lie within the *interpretive orientation* to social inquiry, with philosophical commitments principally derived from hermeneutics and phenomenology, and to a lesser extent from critical theory, systems theory, modern philosophy of science, and other current post-positivist thought. Twentieth-century science and philosophy have abundantly demonstrated the oversimplified nature and highly restricted validity of positivism and its idea of a machine-like universe, with far-reaching implications for social research in fields such as curriculum studies. An interpretive study rooted in phenomenology and hermeneutics constitutes a systematic attempt to discover, describe, and interpret the meaning of lived experience in particular situations. In keeping with hermeneutic theory, an interpretive study also involves the

posing of critical questions and the examination of taken-for granted assumptions and beliefs. Furthermore, the findings of an interpretive study are not presented as generalizable laws, but as a *narrative* about human social life; a narrative with a clear moral purpose, in this case, trying to contribute to our understanding of what is "right " for students and teachers in science classrooms.

The empirical component of the study was a classroom investigation involving two grade 7 science teachers over an eight-month period of a single school year. Data collection, including conversational interviews, classroom observation, and document analysis, centred on the teaching and learning of technology and science-and-society units in the first year of the 1990 Alberta Junior High Science Program. Data was analyzed using a process of thematic analysis, similar to Glaser and Strauss' grounded theory method, but, in approach, more oriented to hermeneutics, phenomenology, and critical theory. The analysis of the Junior High Science Program, the subject of the third chapter, is based primarily on the program of studies and other Alberta Education documents, on documents representing the views of various curriculum stakeholders in Alberta, and on relevant literature on STS education, constructivist psychology, and curriculum debates in the USA and elsewhere. The criteria for analysis include external consistency with the literature and government reports, internal consistency of philosophy, goals, form and content, implications for teaching and learning, and social-political implications.

The analysis of the Alberta Junior High Science Program shows that the curriculum represents a compromise between differing demands on the science curriculum, representing various perspectives on the purposes of schooling (academic, utilitarian, pedagogic), and various assumptions about the nature of knowledge and learning. The program's apparent orientation is towards constructivism (the theory that

knowledge is actively constructed by learners themselves as they try to make sense of their world), and towards science for the informed future citizen. But the form of most of the program of studies and the bulk of the content indicate that academic concerns, such as preparation for future science courses, and utilitarian concerns, such as centralized control of learning were placed ahead of pedagogic concerns in the development of the program. Despite these perceived shortcomings, as a planned curriculum the Alberta program is a significant improvement over the previous discipline-based junior high science courses, in terms of what is right for young people, teachers and society in the 1990's.

The participants in the study, Richard and Susan, are both experienced, successful junior high science and math teachers, working at different schools in the public school system of a small Western Canadian city. Susan and Richard are strongly committed to students' learning and development, spend much time with students outside class time and in sports programs, and have a similar belief in learning science as the process of understanding and applying knowledge. The description, interpretation and analysis of the findings of the classroom study found in the fifth chapter are organized around four main existential themes: *feels right*, dealing with sociality (lived experience of social life) and authenticity; *right answers*, which explores the lived experience of educational freedom; *right stuff*, which is about the bearing of alienation and human context on learning; and *making it right*, pertaining to teachers' pedagogical commitments. In general, both teachers were very positive about the new STS program, because while they did find some discomfort in the transition between different subject matter and teaching roles, they found more satisfaction in a program that seemed to promote a more social, authentic kind of teaching and learning, and provided more interest, enjoyment, and enthusiasm among students and teachers alike.

The constructivist orientation of the curriculum meant more freedom of choice for teachers and students, but it also meant more ambiguity and uncertainty in the classroom. Susan and Richard strongly felt that the new STS curriculum was more appropriate and relevant for their diverse classes, because it provides a human context for learning, and brings the science curriculum closer to students' own lived experience. The meaning of "curriculum implementation" for the participants, was not so much putting plans into practice, but trying to find ways to use the program that supported personal growth and learning for their pupils.

Discussion

In what ways then, do these findings of science teachers' lived experience of curriculum change contribute to our understanding of curriculum issues raised by the study? We have been looking at lived interactions of teachers, students, and subject matter in particular classroom situations. The curriculum change seems to have had a positive impact on classroom interactions for the two teachers and their classes in the study, as well as for other teachers (based on personal communication with administrators, consultants and teachers around Alberta). But what can one say about STS curriculum from this?

In the literature review (chapter 2) and in the curriculum analysis (chapter 3), the current diversity of approaches and orientations to STS education was emphasized. One of the challenges in discussing Science-Technology-Society curriculum is coming to grips with this diversity and answering the question, "what kind of curriculum is this?" The "STS" label, although convenient, may in fact obscure a number of key curriculum issues, for instance: (a) The relative emphasis of science, technology, and society and the exact nature of that emphasis; (b) the nature and degree of integration of the science disciplines; (c) the dominant curriculum orientation(s), or set of societal

demands, assumptions, and values regarding science education addressed in the curriculum; (d) the philosophical assumptions underpinning the program in terms of the view of science and technology presented, and the presence of an ethical or critical perspective; (e) the model of learning which underlies the curriculum; (f) the kind of teaching and learning activities promoted by the program.

Although the foregoing is by no means complete, it does allow an adequate conceptualization of the 1990 Alberta Junior High Science Program for the purposes of this discussion. While the Alberta curriculum is perhaps technically an STS program, in that it does feature some emphasis on *technology* (33% of the program) and *society* (17% of the program), the major emphasis in the program seems to be on concepts from the science disciplines. Unlike some STS programs, there is no explicit material in the syllabus or approved texts on the subject of science-technology-society connections such as the relationship between modern science and technology, or the risks and benefits of technology for society, nor are there integrative concepts linking the science disciplines or science and technology. In Richard's and Susan's classes, the technology unit focused on in the study ("Structures and Design") combined problem-solving activities with the learning and applying of basic engineering and design concepts, while the society unit ("Microorganisms and Disease") emphasized science concepts about microbes, food technology concepts, lab activities on microbes, food spoilage and handling, and a lone societal decision-making activity (whether fungicides should be used on apples). The program has little or no emphasis on ethical or critical concerns relating to science, technology and society, although it does touch on environmental impacts at the grade 8 and 9 levels. In other words this is an STS program with a rather large science-S, a modest T, and a minute society-S.

Alternatively, a case could be made for calling this an "interdisciplinary science" program with some technology and society material, as opposed to an "STS" program, and for noting a certain degree of continuity with pre-STs discipline-based science courses that contained technological and societal references. In terms of actual practice—the materials used, and the teaching and learning activities engaged in—the notion of separate curriculum orientations breaks down somewhat, but there seemed to be an underlying pedagogic orientation to learning, with concepts and activities fulfilling either a mainly academic function (science concepts and activities) or a mainly utilitarian function (technology concepts and activities). However, the dominant features of the "curriculum change" relevant to the lived experience of the teachers in the study are not so much that it is STS, but that it is an interdisciplinary program with a "constructivist" orientation to learning and an emphasis on a variety of hands-on activities.

What then, accounts for the Alberta program's success, relative to the body of literature referred to in an earlier chapter which documents the widespread failure of curriculum reforms in science? The key point, I believe, is captured by Richard's comment, "finally someone paid some attention to kids when they were developing a curriculum." That "attention to kids" is partly embodied in the "constructivist" orientation to teaching and learning found in the syllabus, the approved textbooks, and other materials. Constructivism, as encountered in this curriculum, seems to provide a more realistic, authentic view of how young people learn, and emphasizes what may be missed by other orientations to knowledge: the *quality* of learners' experiences. This view recognizes, as Dewey and others had previously, that students' personal lived experience is central to learning; that science content must somehow be connected to students' lives in order for learning to be enjoyable and interesting, that interaction,

fun, enjoyment, enthusiasm and, in general, a *human context* for learning are necessary.

Paying attention to children also means that concepts like "appropriate" and "relevant" are defined mainly in terms of children and their world, rather than in terms of an academic discipline, the economy, or the current state of society. It must be remembered that we are discussing 12-13 year olds here, so what is appropriate or relevant for 18 year olds may be a different matter. Richard and Susan, as well as the writers of the textbook used (all Alberta junior high school science teachers themselves), seemed to pay attention to finding content and activities that would make sense and interest students of that particular age. As Millar and Driver (1987) put it, "the challenge for science education is to find contexts which are charged with relevance to students' interests and concerns" (p. 56). Furthermore, the program pays heed to the social nature of learning for young people (especially junior high students), to learning as a form of human dialogue.

Besides this, the constructivist perspective of the Alberta curriculum has significance for the question, "what counts as knowledge?" In the more conventional discipline-based grade 7 course which preceded the 1990 program, what counted was contained in the curriculum guide, the textbook, or the teachers' notes, and consisted of terminology, concepts, and principles as conceived by discipline specialists. This was impersonal public knowledge, with little or no scope for shaping or contribution by students. On the other hand, although constructivism implies that learners actively reconstruct meaning from experience, this does not mean that each student must re-discover the insights of Western science single-handedly.

What it does mean is that the educator's job is to bridge the gap between the limited and concrete lived world of the student, and the universal and abstract world of

the scientist. I am reminded that the Latin root of our English word "educate" is *educere*, from *e-* out of, and *ducere*, to lead or bring forth. This means that the teacher must lead students beyond their narrow horizons in the direction of the world as conceived by scientists; to reconcile personal lived experience with its abstracted public version, in order to give both more meaning. Of course it is not easy to balance students' self-constructed knowledge against that of the scientific specialist, considering the nature of most of the school and university science courses teachers have experienced, the threat of external examinations, and so on. However, I do believe that the Alberta junior high curriculum materials (if not the curriculum document itself) promote the shaping of student experience and meaning in the direction of a mature scientific understanding of the subject matter. Richard and Susan seemed to be fairly successful at reconciling student-constructed meanings for certain topics and activities, within the larger context of the specialists' conceptions presented in the text.

A summary of comments from a meeting of Edmonton junior high science teachers' describes the new Alberta program, among other things, as "less content oriented and more activity oriented" (Berge, 1989). For Susan and Richard, this aspect of the curriculum change was a significant aspect of "paying attention to kids" and the program's success. As Millar and Driver (1987) remind us, it is easy to fall prey to an oversimplistic dichotomy between *content* on one hand and *process* on the other. They argue that if learning is defined as the personal reconstruction of knowledge rather than rote memorization, then learning content always involves processes. Conversely, Millar and Driver contend that scientific processes, such as observing and hypothesizing, are neither generalizable or transferable, but are contextual and therefore cannot be divorced from content. What this means is that a stronger orientation towards activities, process, or "science as knowing" (as Richard phrased it earlier) does

not stand in antithesis to content. "Less content oriented" simply means that there is less content learned by rote memorization, and more content being applied, thought about, and reconstructed in activities. The expression "hands-on, minds-on" comes to mind: activities observed in the program and described by the participants occurred in the context of particular content, and involved some kind of thinking and engagement with the material. The variety of activities available in resource materials represented pluralism not only in content, but also in the kinds of processes and thinking involved—everything from testing cement mixtures and yeast growth factors to writing a poem and designing a space station. This approach acknowledges that children need contexts for learning that engage both mind and feelings, are varied, interesting and challenging.

There seems to be some lingering skepticism among science teachers, university scientists, science educators and others about any movements away from the conventional science sub-disciplines of biology, chemistry, physics, and earth science to a multidisciplinary "science" approach in secondary schools. The findings here seem to confirm the legitimacy of interdisciplinary science, at least for the younger, non-specialist secondary student. Both Susan and Richard feel strongly that this approach is more suitable for their grade 7 students in terms of being more representative of the scientific enterprise as a whole, maintaining students' interest, and addressing student diversity. The move away from the disciplines also raises the issue of who school science is for—whether secondary science education should be a select few or for all students. Again, the participants' experience of the Alberta STS program suggests that a good part of the program's success is found in its ability to address student differences in gender, learning style, academic ability, background and so forth.

"Science for every student" does seem a realistic goal, given the right kind of curriculum.

Part of the thrust for rethinking science education has been the consensus among philosophers of science, scientists, and curriculum writers that science education was not presenting a realistic view of modern science and technology, especially in view of the rapidly changing workplace and the pervasivity of science/technology-related environmental and social issues. It is difficult to assess from these findings whether students taking this program have developed a more authentic view of science and technology. Discussion of aspects of the nature of science and technology is not explicitly promoted in the program either through specific learning outcomes, or through activities and questions in the textbooks. However, a case could be made for the implicit development of more authentic science and technology concepts, by virtue of the constructivist disposition of the program and the activities carried out by students. When students are engaged in scientific inquiry or technological problem-solving, arguing about hypotheses and interpretations, creating alternative procedures, deciding on the best explanation, it does seem at least as likely that they would come away with a view of a science as tentative, subjective, value-laden and socially constructed, as they would under a regime of "didactic teaching" directed at this same outcome.

A similar argument could be made regarding the STS goal of developing informed decision-makers. In the science-and-society unit observed ("Microorganisms and Food"), students at one point were involved in making decisions about an issue on the basis of available information, albeit a non-controversial issue. Even allowing for more activities of this type in the ensuing two years of the program, the degree of transfer of "informed decision-making" of this nature, to the benefit of society in later

years, can only be a matter of conjecture. One can say it seems more likely that students would be informed decision-makers as adults, having had such experiences in junior high. It should be re-emphasized that one of the significant implications of constructivism is the indeterminacy of learning, and the need to be satisfied with probability rather than certainty in explanations and predictions about learning. The wider set of curriculum goals associated with STS education in general, and with the Alberta curriculum in particular is certainly addressed by the program materials, by classroom activities and by various evaluation methods in Susan and Richard's classes. Beyond the ability to demonstrate knowledge and skills in concrete situations in the classroom, determining whether or not this diverse set of goals has been achieved by students must remain to some extent uncertain—a matter of hope, if not faith.

Up to this point in the discussion we have primarily focused on the relationship of the findings to STS curriculum issues. It is now necessary to now look at some wider curriculum issues. To begin with, a perennially contested point in the curriculum literature is the nature of teaching and learning. From the early twentieth century until today, some curriculum writers such as Bobbit (1918), Tyler (1949), and Tanner and Tanner (1980), have assumed that teaching is primarily a *technical act*: the efficient carrying out of curriculum ends prespecified elsewhere, for which the most appropriate curriculum metaphor is *production*. Other curriculum authors, from Dewey (1916/1966) to Aoki (1983), Goodlad (1984), and van Manen (1990) have argued on the contrary that teaching is a primarily a *practical act*, in the sense of morally-oriented human interaction for which the goal is "right action." What this account of Susan and Richard's lived experience of curriculum change tells us is that classroom life is primarily a form of social life, rather than a form of production. As soon as one accepts that lived experience of teaching and learning in the classroom belongs to a

personal world of quality and concreteness, that young people, like all humans, are social beings, that learning in the non-trivial sense of the word is framed by feelings of joy, enthusiasm, and interest, the production concept of learning becomes untenable. We have also seen how curriculum implementation is conceived by Richard and Susan in terms of "making it right." Although they did feel a responsibility to "follow the curriculum," these teachers attended above all to the here-and-now needs of their students both as individuals and as classes. Classroom life for Susan and Richard, as case study research has previously shown (Jackson, 1968; Lortie, 1975; Olson & Russell, 1984), is framed by ambiguity, uncertainty, tensions and contradictions. But this kind of sociological description of classrooms often concentrates on technical aspects of teaching such as "coping mechanisms," and seems less attentive to dimensions of human social life in teachers' lived experience.

Being responsible for children's growth and development (if the responsibility is taken seriously), means that the teacher must respond to "first needs first," as Susan's principal put it, to their needs as fellow human beings. And while keeping other considerations in view, such as personal, administrative or parental concerns, the teacher must constantly make decisions about the "right action for the circumstances." Spending time with children in classrooms is also a lived world of quality, with feelings such as anger and frustration possible on one hand, but also with the hope, joy, interest, satisfaction and human ties that make teaching a vocation and not just a job. Like other research guided by the premises of positivism and the machine metaphor, the technical notion of "teaching as production" is a gross oversimplification; teaching may partly be a technical act, but there is much more to it than that, namely, the human dimension.

One of the fundamental curriculum issues involves the question: "what knowledge is of most worth to society?" As Goodson (1983) and Kliebard (1987) have shown, various interest groups representing different perspectives on this question have competed for control of the school curriculum during this century. The academic/humanist tradition (Goodson, 1983/Kliebard, 1987) values abstract theoretical knowledge for the development of reasoning powers, and the passing on of the best aspects of Western culture. The utilitarian/social efficiency tradition (Goodson, 1983/Kliebard, 1987) values knowledge that is directly useful in the workplace and economy, and advocates the principles of scientific management for schooling, while the pedagogic/developmentalist tradition (Goodson, 1983/Kliebard, 1987) assumes that the natural development and learning characteristics of the child are the most important basis for curriculum, so that the child's own personal socially-constructed knowledge is of most value. Kliebard's fourth curriculum tradition, the social meliorists (1987), who focus on schooling as a means of redressing social injustices and improving U.S. society, apparently has no significant equivalent in the U.K. or in Canada.

In the curriculum analysis of the Alberta Junior High Science written curriculum (chapter 3) it was argued that elements of three curriculum orientations—academic, utilitarian, and pedagogic—were present. The academic tradition was represented in the relatively large amount of content from the scientific disciplines found in individual units, providing preparation for future science courses. The program of studies, mainly consisting of "specific learning outcomes" (learning objectives), with no mention of teaching or learning activities, demonstrates the presence of governmental social efficiency thinking in its attempt to control knowledge in the classroom. Finally, the pedagogic tradition reveals itself in the program's constructivist perspective on learning, encountered in the legitimating rhetoric in the introduction to the program of

studies, but more importantly, giving direction to the writers of the two authorized textbooks and other resource materials, and to inservicing for the program. Though the inevitable result of curriculum compromise is that the program of studies seems to give mixed or even contradictory messages about teaching and learning, in practice, the pedagogic orientation seemed to prevail, at least in the absence of standardized testing or other overt technical methods of control.

Richard and Susan's classroom experience of Alberta Junior High Science strongly supports the legitimacy of a pedagogic orientation to curriculum, that is an orientation to children's growth and development. From my experience of discussing science curriculum issues with representatives of the three dominant interest groups on an STS curriculum committee, it seems to me that all three groups now have a common interest in well-educated young people with a positive attitude towards science, who will be informed decision-makers, and who are knowledgeable, skillful, and adaptable. Whether the goal is achieving higher enrollments of students in post-secondary science and technology, or producing graduates with the qualities needed for tomorrow's workplace, the findings of this study suggest that both goals are more likely to be achieved when curricula incorporate a realistic pedagogic view of learning, address personal, academic and social goals for education, and provide opportunities for students and teachers to have positive experiences of learning science.

So far we have been re-evaluating the findings of the study in terms of significant curriculum issues. It now remains to provide a critical overall evaluation of the study. Firstly, how do the findings relate to other studies of STS curriculum in schools? A recent study investigated the Science and Technology 11 course in British Columbia, introduced in 1986. Gaskell (1989), who conducted a case study of the reception of this course by teachers in an urban school district, found that while a few

teachers supported the course, in general, neither the science teachers or non-science teachers involved in ST 11 enjoyed teaching the course, but tried to avoid the course and teach the discipline subjects with which they identified most.

There are several points of difference, however, between Gaskell's study and this study. Firstly, the age groups (grade 11 versus grade 7), and targeted student populations (non-academic students only versus all students) differed. Secondly, the ST 11 course is basically a discussion course focused on STS issues, with little academic science content, and no practical activities (Gaskell, 1989), whereas the Alberta program has a greater emphasis on science content, technological and science inquiry activities, and less emphasis on discussion of STS issues. Thirdly, most of the ST 11 teachers had been displaced from teaching physical education, home economics, and industrial arts by the addition of ST 11 to graduation requirements for the non-university-bound, and the remainder were the most junior members of their department, thus their commitment to the course could be marginal. The major problem with the course for these high school teachers seemed to be its lack of academic status: it was not preparatory to university courses, the content was perceived by one science department head as "pseudoscience," and it involved only academically less able students.

Mitchener and Anderson's case study (1989) of the implementation of a junior high STS program in the U.S.A. revealed similar findings to Gaskell's study, and for apparently similar reasons. The authors found relatively little change in teaching practice among the fourteen teachers involved in the study. Although about a third of the teachers "accepted" the program and made few changes, most of the teachers either rejected it or had "mixed feelings" about it, making significant alterations to the course along the lines of adding traditional content and reverting to more didactic teaching

methods. Many teachers felt the course was a low status course, not "real science." This is likely because the course was geared towards the academically less able student, had a heavy emphasis on cooperative learning, and contained "applied science" content with unit topics like technology, survival, energy, and land use.

It could be argued that in the Gaskell and Mitchener & Anderson studies, the content and methods of the new STS courses were too radical a departure from the conventional pattern for most science teachers, whereas the Alberta program retained some continuity with previous subject matter and practice and hence was more acceptable. Secondly, in the Alberta case, the relative status of the STS course seemed not to be an issue, not only since the content and delivery were more akin to "real science," but also because the course incorporated students headed for post-secondary education, while no higher-status alternatives were available to teachers.

Beyond these issues, the three STS case studies taken together are illustrative of the range of research perspective travelling together under the rubric, "case study." The Mitchener and Anderson case study, which is from the teacher cognition perspective, focuses on factors affecting decision-making. The rationale is to gain an understanding of teachers' thinking in order to overcome teacher "resistance" to curriculum implementation. This seems an example of the technological genre of curriculum research which carries on the search for more effective ways to manipulate teachers. Gaskell's case study, based on Goodson's (1983) ideas about the dynamics of subject matter communities, seems to be an instance of interpretive curriculum research that concentrates on the sociology of academic communities, but is silent on ethical and critical issues. This interpretive case study examined the phenomenology of individual teachers' everyday experience of curriculum change, but with an ethical and critical

perspective. Here we have three studies looking at STS curriculum change in schools, but with divergent perspectives and findings.

The divergence between the findings of the present study, and those of the other case studies described above, naturally raises the issue of validity. How trustworthy are the findings, and how sound and reasonable are the interpretations and arguments, and why should they be accepted? It must be conceded that the study only partly addresses many of the issues raised. The small number of participants, the limited time span of the study, and the relatively small number of recorded conversations limited the amount and richness of data that was collected, and consequently the depth of understanding derivable from it. A greater understanding of the lived experience of this curriculum change would have been possible had students also been engaged in recorded conversations. And the emergent nature of a study of this type, may have at times during the data gathering lead to a lack of clear focus. Also the theoretical formulations that are offered can only be regarded as preliminary.

On the other hand, I have a fair degree of confidence in the accuracy of the findings and the acceptability of the interpretations from the point of view of the participants. The interpretive validity or face validity (Lather, 1986; Maxwell, 1992) of the results was assessed by recycling the transcript data and early drafts of interpretations back to the participants for their approval, which was forthcoming in each instance, and in the case of Richard, also included clarifications which were included in the findings. I would argue that triangulation, or validity checks through multiple data sources, methods and theories enhances the credibility of findings, and the researcher's own classroom experience as a secondary science teacher, including two years teaching the pre-1990 Alberta junior high curriculum, could be regarded as an additional data source against which to evaluate the findings and interpretations, as

well as a data source for phenomenological reflection. Likewise the many similarities in the researcher's background and perspectives and those of the participants, would tend to provide other commonalities of experience and conceptualization. In addition, the critical analysis of the written curriculum (chapter 3) could be seen as not only an additional source of data, but also an alternative methodology.

I would argue that the integrative and holistic approach taken to theory is a strength of the study; an attempt at theoretical consistency which encompasses philosophy of science, systems theory, the interpretive social research perspective, phenomenology, learning theory, and total quality management, and post-positivist thought in general. Thirdly, it might be argued that the openly normative stance of the study enhances its credibility and relevance. The purposes and values of the study are openly avowed, which can then serve as a reference point or bias check for the reader, and more importantly, the theme of questioning what is "the good" for young people, surely addresses the moral centre of education. Finally, I would submit that the credibility of the interpretations ultimately resides in the interaction between the reader and the text. Since the knowledge claims in the study are about realms of human experience shared at least partly by any reader (Polkinghorne, 1983), their credibility can be measured against the reader's own lived experience. To paraphrase Heidegger, it is not so much what we do with phenomenology that concerns us, but what it can do with *us*.

Implications of the Study for Curriculum Theory and Practice

A number of different approaches to curriculum research are followed. Can a phenomenological analysis of curriculum change provide a fruitful perspective, which might enrich our knowledge of curriculum? The first point to be made is that phenomenology, unlike reductionist approaches that abstract certain things from the classroom situation such as how students learn, or how teachers make decisions, attempts to deal with the wholeness of educational phenomena (van den Berg, 1974), and to offer the holistic perspective necessary to deal with complex social systems such as classrooms (von Bertalanffy, 1975). A phenomenological approach which arises in teachers' accounts of their own lived experience is necessarily grounded in concrete classroom practice, and seems more likely to be able to play a role in closing the perceived gap between curriculum theory and practice (Klein, 1992). Further to this, it has been argued by writers from diverse perspectives (Fullan, 1991; Olson, 1982; Vandenberg, 1975) that disruptions in practice, such as curriculum changes, are particularly revealing regarding insights into educational practice. Most importantly, phenomenological studies which examine classroom situations where "education" in its broad sense is actually occurring, would seem to provide a more secure basis from which to offer a normative perspective—what *should* be done to improve practice.

The basic insight of educational phenomenology is the fact of the pedagogic relationship: "a relationship between an adult and a child in need of help that is constituted as a distinctly pedagogic relationship by the presence of nonauthoritarian authority" (Vandenberg, 1975, p. 204). This study of curriculum change presented an opportunity to explore that relationship in the context of two contrasting Alberta junior high science curricula: the pre-1990 discipline-based, content-heavy program, and the 1990 interdisciplinary science program whose most salient characteristic is a

constructivist orientation. In fact, the juxtaposition of the two programs during a curriculum change enabled a kind of dialogue between different conceptions of curriculum, their attendant assumptions, values and metaphors, and the lived experience of their consequences in the classroom. One such consequence was that the new program "felt right" for the two teachers in the study, in that it seemed to recognize and promote learning as a natural outcome of interactions among teachers, students, and their world. In other words, in conceiving learning as the reconstruction of meaning from personal lived experience, the curriculum played a role in returning teaching and learning to *a more human and less technical context*, so that the subject matter was perceived by the teachers as more appropriate and relevant, and by both students and teachers as more interesting, enjoyable, and educative. It might be argued from this that a concept of learning, whether didactic transmission of knowledge, or constructivism, is much more than just a concept of learning, for has the potential to shape and modify a whole range of interactions in the classroom: between teachers and students, teachers and knowledge, students and their world, and among students. This insight suggests that a constructivist orientation to learning should be a feature of curricula when not only genuine learning, but the overall quality of the pedagogical relationship and classroom life is a concern.

The theme "right answers" indicates that a constructivist curriculum contains further consequences for the teacher-pupil relationship in the classroom. For if a constructivist perspective involves learners in actively constructing meaning through interpersonal negotiation (Driver, 1988), then exact learning outcomes cannot be specified according to a linear means-ends model of curriculum development. This means more freedom of choice and flexibility for teachers, so that instead of trying to transmit a mandated list of facts and terms to students, or planning in the mode of

technical rationality (Schön, 1983), teachers are able to follow the interests and needs of their students. Although greater freedom also means greater responsibility, uncertainty, and ambiguity for the teacher's classroom life, it nevertheless provides the conditions necessary for teachers to facilitate meaningful learning for their pupils. In other words, if meaningful learning and constructivism are to be taken seriously, curriculum developers, administrators, and teachers should put aside current practices emphasizing control, uniformity, and standardization such as prescribed curricula, prespecified learning objectives, and standardized tests. Instead, alternatives should be adopted that acknowledge the personally and socially constructed nature of learning and the freedom necessary for teaching and learning to be truly educative. For instance, besides broad generic aims and a relatively small number of essential concepts and skills, a curriculum document would consist of a programme of suggested teaching and learning activities, materials, and resources from which teachers could choose alternatives to promote meaningful learning in their particular educational situation. This of course implies less control of curriculum by educational bureaucracies, greater autonomy for teachers and students, and therefore a greater degree of trust from various educational stakeholders regarding the notion that learning is enhanced or even possible under conditions of freedom.

These implications of constructivism for teaching practice coincide closely with the way the teachers themselves conceived "curriculum implementation." They saw their role in introducing a new curriculum to their classes as "making it right"; that is, modifying the curriculum, not to make it more efficient, more faithful to the planned curriculum, or easier for themselves, but so as to best meet the needs of their pupils as learners and human beings. There is, therefore, a basic conflict between the purposes of curriculum implementation conceived by the scientific management perspective as

"putting a reform into practice" (Fullan, 1991), and the purposes of teachers such as Susan and Richard who are committed to students' growth and development. One way to at least partially resolve the conflict is to reconceive curriculum development as "practical action," or morally oriented human interaction. Attempts to standardize and control human social life, including pedagogical relationships in the classroom, ultimately cannot succeed, besides being inappropriate in a democratic society. Rather than focusing on students, teachers, and curricula as isolated variables or products to be manipulated, curriculum planners should concentrate instead on the quality of the interactions in classrooms, and on ways of facilitating improvement in the quality of those interactions.

But is this feasible, given the apparent entrenchment of technical rationality in education? Scientific management or "Taylorism," which is quickly being abandoned by successful businesses and industries in Canada and the U.S. on the pragmatic grounds that it doesn't work in today's world, is now being replaced by the principles of Total Quality Management or similar schemes which stress improvement in the quality of human interactions (Bowles & Hammond, 1991). Quality management initiatives in public schools, including school systems in Alberta, focus on people and on "the quality of the school *as an experience*" (author's italics), not on technology or curriculum packaging (Murgatroyd, 1989, 1992). Although the difficulties of redefining the organizational metaphor for curriculum development from that of the "machine" to a more accurate and humane alternative are not to be underrated, and although caution must be exercised in borrowing ideas from the world of business, I would suggest that this is the general direction to be pursued in curriculum development.

The juxtaposition of two conceptions of curriculum during a curriculum change revealed that for the teachers in the study, the 1990 program was the "right stuff" for their students: more appropriate and relevant. This theme speaks of the necessity in science curriculum for *connectedness* between students' lived experience and science subject matter, so that when curriculum developers, textbook writers, or science teachers are selecting subject matter, (1) they should have an idea of the nature and range of experiences and interests likely to be found among students in a particular time and place, and (2) they should choose science subject matter which has the closest possible relationship to those experiences, bearing in mind situational knowledge of student diversity in gender, backgrounds, interests, abilities, needs and so on. The rationale is that the more linkages and points of contact there are between pupils' knowledge and scientific knowledge, the greater the likelihood of students' moving away from the narrow world of their lived experience towards a more mature conception of the world which benefits from the insights of science. This implies that large-scale "universal" curriculum projects are less likely to succeed than smaller-scale local projects which incorporate teachers' practical knowledge of particular situations and students. I would suggest that this is one reason why the Alberta junior science textbook written, piloted and revised by Alberta teachers (Durward, 1989), has been more successful with students and teachers, judging by textbook sales and this study, than a textbook written in a different region of the country by university educators (McFadden & Morrison, 1989) or previous junior high science textbooks authored in the U.S.A..

This is a time in education, as in many other fields, when people are coming to realize the shortcomings of the world view based on the machine metaphor, and the social practices that have accompanied it. Post-positivism, often referred to in this

study, offers many important and exciting insights to the curriculum field, yet as a body of thought or paradigm to guide research and practice, is in some ways amorphous, and lacking a clearly articulated set of images, metaphors, and exemplars. The theme of "connectedness" just alluded to, is a reminder that a possible direction is provided by the notion of "systems thinking," its associated principles, and the "organism" metaphor.

That biological entities with emergent qualities, such as we human beings, have been sidetracked for centuries by the machine world-view seems an ironic denial of nature. But many people are beginning to realize that *holistic* approaches to social research and practices, and that theoretical approaches based on biological wisdom and the notion of open systems are powerful and effective. If we consider classrooms, schools, or school districts as complex open systems, and focus on the *quality* of human *interactions* and *processes* that occur within them (as Schwab suggested decades ago), rather than on separate components or products, then we are on the road to a more realistic and humane approach.

One highly relevant systems principle for curriculum is that all healthy systems have two opposing tendencies held in *dynamic balance* (Capra, 1982). The first tendency is towards *maintenance*, conservatism, and continuity with the past, the biological analogues of which are the processes of homeostasis, self-renewal and repair which attempt to maintain the status quo of the living system despite changes in the outside environment. The second and opposite tendency is towards *transformation*, which relates to the need for systems to change in order to survive in a changing environment. In living organisms, this means growth and development, learning, adaptation, and evolution. Clearly an overemphasis on either tendency in a living system would not be healthy, since to ignore maintenance leads to a breakdown in the

stability necessary for normal life processes, and to ignore transformation renders a system helpless to respond to longer term and more drastic change—inflexible and unable to adapt. The implication for curriculum seems clear, and is reflected in an earlier discussion of the apparent success of the Alberta Junior High program: successful curriculum change maintains sufficient continuity with past practice balanced by transformation sufficient to respond to change, albeit in an incremental, not revolutionary fashion.

Much further research is needed to clarify the nature of classroom life, curriculum change, and science-technology society education in different settings. In Alberta, follow-up interpretive research is recommended with additional junior high school science teachers to determine how classroom life and practice may or may not have been transformed over a longer period of time. Research which looks in depth at students' experience of this curriculum change and other curriculum changes is much needed to obtain a more holistic view of the dynamics of change. Still in Alberta, a new senior high school STS course was mandated in 1992, with a very different set of interactions among social-political context, subject matter, students and teachers. What would a phenomenological investigation of teachers and students experience of this change reveal in comparison to the junior high case? To strengthen further phenomenological studies I would suggest a more systematic use of the dialogic procedure recommended by Vandenberg in which an adequate description of phenomenon is obtained by arguing its antithesis, opposite, or lack of, in order to obtain a more objective and enriched description. In addition, a more rigorous use of Bollnow's three-fold methodology (1972) should have a similar effect in strengthening validity and obtaining richer descriptions: (a) linguistic analysis, (b) phenomenological description, and (c) categorical analysis, which locates the phenomenon in relation to

other phenomena of lived experience, similar and dissimilar, and in relation to the larger educational context.

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APPENDIX 1

Introductory Letter to Administrators and Teachers

Science Education Research Project:
'An Interpretive Study of STS Implementation'

The Researcher:

My name is Keith Roscoe, and I am presently a Ph.D. student in the Department of Secondary Education at the University of Alberta, on sabbatical leave from Grande Prairie Regional College, where I teach science in the Department of Academic Development. I have had fifteen years of varied experience in science teaching, including six years at the junior high level. During my Ph.D. program I have taught courses in general secondary methods (ED CI 352) and science methods (ED CI 369/374), have worked with student teachers, and have carried out two research projects in Edmonton schools.

I am committed to understanding and improving practice in science education, thus I am very positive about the potential of the new junior high science program to provide meaningful, interesting and educative learning opportunities for young people. Presently, I am a member of the ATA science council, and serve on the Senior High Science Advisory Committee, and on the Biology 30 Examination Committee. My dissertation advisor is Dr. Ken Jacknicke (492-3674), chairman of Secondary Education. Other committee members include Dr. Wallie Samiroden and Dr. Pat Rowell. I return to my position at Grande Prairie Regional College in August 1990, and hope to sit my candidacy exam in November, 1990.

Purpose of the Project

As we approach the twenty-first century we are living in an increasingly crowded and polluted world. Responding to present environmental and social conditions, science education in many countries is now shifting its focus towards science-technology-society (STS) education. STS programs bring a number of changes into the science classroom: changes in content, teaching methods, and student-teacher role relationships. In 1990, Alberta science teachers will be implementing the new grade seven science program in their classrooms.

This study will investigate how junior high science teachers respond to the new grade seven science program, and why. It will be an attempt to develop a deeper understanding of teaching practice in the context of an STS program, from the teachers perspective. In the light of repeated failures of previous curriculum reform efforts in science, we need to know more about the feasibility of STS science in junior high. What are its strengths and weaknesses from the point of view of classroom teachers? What new problems and dilemmas does it introduce? What modifications are necessary for classroom use? Do science teachers change their practice when an STS program is introduced? Why, or why not? These are the issues which the project will address.

Research Orientation and Procedures

The research orientation is qualitative and naturalistic. I am planning to conduct case studies with three grade seven science teachers from different schools and with a range of backgrounds, experiences, and beliefs. Naturalistic case studies involve gathering data from classroom observation and interviews of teachers going about their normal daily teaching routine. That is, the research does not involve trying to change or manipulate anything that occurs in the classroom, or evaluating teaching practice against some ideal standard. The emphasis is on attempting to understand classroom events from the teacher's viewpoint.

The actual research procedure would involve my observing as many lessons as possible from two units in grade seven science (Unit 2: Structures and Design; Unit 5: Microorganisms and Food Supplies). I would observe from 3-5 lessons a week in one or two grade seven classes with a specific teacher. Also, I plan to have a 40-60 minute conversation with each teacher at least every second week, during which my observations would be a starting point for exploring the teacher's perspective on classroom events and the program in general. The "interviews" will be more like informal conversations between colleagues than formal interviews. Details of the methodology, in keeping with the spirit of this orientation to research, would be negotiated with the teacher. The exact timing and time commitment would vary, depending on when the two units were being taught, and how long the units would take. But the likely time frame is a total of 8-12 weeks of commitment, somewhere between October 1990 and April 1991.

Ethical Considerations

Participation by teachers would be entirely voluntary. Teachers would be free to withdraw from the study at any time. Anonymity of participants and confidentiality of information will be safeguarded at all times, since pseudonyms will be used for participants, schools and boards, and locations will be disguised in the field notes and research reports. The exact methodology, data to be gathered, time commitments and so on, will be negotiated with participants. Interpretation of data will be a result of consensus between the researcher and the participant, and participants will be free to modify or remove any information from the data gathered. The objectives of the research will be communicated to stakeholders: central administration, board, principal, teachers, students and parents. Excerpts from the completed dissertation, and copies of published reports will be available to participants. A research contract will be negotiated with the participants, dealing with these ethical issues.

Potential Value of Project to Board, School, and Teachers

I will be glad to offer whatever help I can provide at the board or school level, in the form of talks or workshops on topics relating to the new science curricula, and science education in general. For the individual teacher, I can offer materials which I have gathered on STS teaching strategies, and ideas on approaches for STS. I would be glad to occasionally act as a teacher's aide in the participating classes, and would love to teach some classes. Teachers participating in studies of this type report that they benefit from an opportunity to talk about and reflect upon their work with a sympathetic, informed, non-evaluative colleague—an opportunity for new insights and professional growth. As far as the findings of the study go, I believe that the kind of knowledge which can be provided by this study is essential for policymakers,

curriculum developers, school officials and teachers to bring about *informed* improvement of science education.

For more information, please contact:

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After August 1st 1990: 10249 113 Ave, Grande Prairie, T8V 1W9. 538-3396 (home) 539-2095 (office)

APPENDIX 2

Orienting Questions for Conversational Interviews

I. Participant's Background and Personal History

1. Tell me about a bit about yourself—family, background, interests, important events in your life.
2. What experience have you had in teaching science?
3. What was it like for you as a child at school? At university?
4. What is your educational background in science and science education? In other subjects?
5. How did you get to be a teacher? What made you decide to teach science?
6. What subjects do you presently teach? Which science courses do you teach? What subjects have you taught previously?
7. What involvement have you had in science education professionally? (Professional organizations? Conferences? Curriculum committees? Piloting programs? Science fairs? Other involvement?)
8. Do you know much about the new grade seven science program? STS education? Attended inservice activities? Read anything about it?

II. Participant's Views of Teaching, Learning, Students, and Subject Matter

9. What does it mean to you to "teach science"? If you teach other subjects, is teaching science different? How?
 - Can you think of any specific instances that exemplify science teaching to you?
 - Tell me about a time when you felt you were really successful in teaching science.
10. What does it mean to you for students to learn? To learn science? Is learning science different to learning other subjects?
 - How do you know if students have learned?
11. How important is it for students to learn science?
 - Do students find science easy or difficult? Do they enjoy science?
12. What does science mean to you?
 - How do explain "science" to your students?
 - What is your view of scientific knowledge? How is it different from other kinds of knowledge?

13. How would you describe your students?

- Are grade seven students different from other grades?
- Have students changed since you first started teaching?

III. Participant's Views of Science-Technology-Society

14. What are your questions and concerns about the new program? STS education in general?

- Some science teachers say that STS isn't real science teaching. Is it to you?

15. How is the new program different from the old program for you?

- What is it like for you to teach the new curriculum?
- Can you think of any specific instances when you thought the new program was really successful? Less successful or disastrous?
- Has the new program produced any new demands and dilemmas for you as a teacher? How are you addressing these?

16. Is this the "right" thing for your students to be learning? Is it worthwhile for them?

IV. Participant's Meanings for Classroom Events Observed by Researcher (example questions)

17. What was it like for you when.....this afternoon in 7B?

- How were you experiencing it?
- What were you thinking and feeling?

18. When you said "....." this morning to Jason, what were you thinking and feeling?

19. Can you tell me about this lab handout/board note/test ? What was your thinking behind it?

APPENDIX 3

Sample Field Notes

1. Fieldnote

Oct 23, 1990

Interview: Richard. (Interview # 1)

Richard's House 7:00-8:15 pm

Arrived at R's house about five minutes late, but this did not seem to be a problem. We went to talk at the kitchen table, where we had had our preliminary discussions about the project in September, and where C. does his preparation and marking. The house was very tidy as usual, but he apologized for its state. The radio was playing softly in the background.

First I went over some preliminary issues and considerations as suggested in Patton.

R. seemed to think he was pretty clear on the purpose of the study from reading the second draft of my research proposal. To be on the safe side I quickly reiterated the purpose: to get his perspective on the new curriculum, the changes, demands, dilemmas, advantages, and so on that it brings to the classroom. Then I went over issues about protection, confidentiality, and anonymity—false name, school, city, no discussion of data with family, friends, colleagues, administrators, only committee will see data before publication, you don't have to answer questions, and so on. We looked at ownership of data—participant has final say over release of data, can add own interpretations if not happy with mine, will discard tapes and field notes after the study is complete in its final form. R. seemed to have no problems with any of these issues, in fact seemed surprised at my bothering with some of it. Finally after a few words about the tape recorder (R. used a tape recorder extensively in his masters research) I pointed out the off switch and said he could turn it off at any point if he wished.

R. seemed to be very comfortable and not at all reserved or nervous, I had a little trouble relaxing at first and was perhaps a little bit more formal at first than I really wanted to be. As the conversation went on it seemed to flow a little better, I relaxed, and R. even anticipated some of my questions, so I didn't have to do too much asking. R. was very fluent and articulate, seemed to understand my purpose and questions, and gave quite reflective, in-depth answers to several questions.

Assessing the focus and content of the conversation, it seemed to be very successful in addressing the initial questions I had chosen for the session:

- Present teaching load
- Typical teaching day/routine
- Response to new science program
- How new program compares to old JH science program
- Previous knowledge of program
- Background: teaching experience, university education background, entry into teaching

The only planned area we didn't address fully was C's presuppositions and expectations about the program before teaching it, and how these compared with his actual experience.

I took notes—4 1/2 pages of them—and tried to capture key points, phrases, some quotes, my questions, as a basic outline in case of tape failure, and as a reference during and after the interview in order to monitor progress. I don't think I was fully successful with the notes, and found that it interfered with my concentration and the flow of talk. I shall persist with skeletal notes for a while, however, because of the security and monitoring advantages.

Thoughts/Reflections:

With teaching six out of seven 47 minute periods every day, as well as spending up to 2 hours a day recently on volleyball, time is a big factor in R's teaching life. It appears that the program change hasn't been a big transition for R either in math (we talked a bit about the new math program) or science. He was previously doing a fair bit of discussion in science along with typical content-oriented methods, and his coursework, reading, and thesis in his M.Ed. program changed his ideas and attitudes about teaching math and science towards a more constructivist view. He said "it seems obvious" to make learning concrete, personal and relevant for kids this age. The new textbook (Science Directions 7) has been a big success with both R. and his classes. He likes it because it there is more than enough material and activities, at appropriate level, in an appealing form. The text simplifies planning and preparation, and is a good motivator for kids because they find the book appealing, the amount of text not overwhelming, the examples and activities interesting and worthwhile, and so on. Program and text lend themselves more to flexibility and following student interests than the old discipline and content-rooted JH programs and texts, for R.

It seems that R. is a "born teacher—his mother taught and inspired from her example, he always liked explaining things in school, and he "really likes going into the classroom in the mornings". Teaching was a way to carry on doing the things he really enjoyed—eg math and volleyball. I was also reminded in our conversation of R's commitment to the notion of "authenticity" in teaching and curriculum: a concept we had discussed quite extensively last summer in a grad course we took together. R sees his teaching as "a reflection of self", not a separate persona, style, or tone—it must be a completely authentic act. Even if he has modelled his teaching strategies to some extent on others he has observed, it is always his own style. He also sees this as important in the math and science curricula—that curricula/learning must also be authentic for the kids as well—real, concrete, personal, relevant—also a reflection of *their own selves*, not just of the text, the teacher, or impersonal "public knowledge", as was perhaps the case with the discipline-centred previous courses.

2. Fieldnote

Susan Observation # 1
November 19, 1990

Arrived at about 1:33 as class was just starting an activity—the presentation of their plant models to the class. This is the 7A class, which has science in the mornings twice a week in the afternoon, and three times in the morning. The other class, 7B, has science three times a week in the afternoons, so I probably will be seeing more of them. The 7A's may have been waiting for my arrival, as it was 25 minutes or more into a double block, and they were sitting quietly at their desks with their imaginary plants and accompanying notes in front of them. I took a desk at the back, received an evaluation sheet, and the first presenter began.

S's classes, who are using the Wiley text, are still working on the first unit, Characteristics of Living Things. They are a few weeks behind, since M was very sick and had to miss a few weeks. The activity they had been engaged on was "Invent a Plant", Activity 1-21 in the text, which reads:

"Construct an imaginary plant (or one modeled on a real plant) that is adapted to survive under certain environmental conditions." (eg, survive mowing, drought, high winds, store water, catch insects, etc).

The textbook suggests "evaluate either your design or that of your classmate". S had adapted this to a format in which the whole class evaluated each person's plant, using an evaluation sheet with a space for name, mark (/10), and comments. Each student would get up in front of the class, with a few minutes to describe their plant's adaptations, and answer questions posed by the other class members. They did a very competent job, and most, surprisingly, didn't seem terribly nervous,

[OC: I had some difficulty attaching a mark to the projects on my evaluation sheet, mainly because I had no idea what the criteria were. The kids certainly had a good idea of some aspects of biology, but had more limited notions of energy and reproduction.]

Quite a number said that their plants lived off water, and almost none mentioned sexual reproduction—mostly asexual reproduction. The plants were very creatively and imaginatively done in playdough, wire, paper, styrofoam, etc. The kids' questions were pretty routine stuff: how do they eat, how do they protect themselves, how do they reproduce? During the questioning I had a chance to look around a bit at the classroom.

S's classroom is an interesting setup, combining a regular classroom with a lab area, with an attached greenhouse and a prep room. The classroom has about conventional 32 desks in 6 rows, facing a blackboard and demonstration bench. The lab benches do not seem to be currently used for lab work, being completely occupied by 2 large fish tanks, about 50 imaginary plants on display, and various boxes and miscellany. The room is 5-sided, and actually is half of a symmetrical arrangement of 2 science rooms. The lab half of the room has a T-shaped lab-bench island, with stools. Around 2 sides of the room are benches with storage cupboards and shelves. above. There are 4 cages with snakes of various kinds, and all sorts of other things on every available

surface, including a large number of file boxes and cartons on the floor at the sides of the room. There are posters on the walls, and it generally gives the impression of a cheerful, busy place.

The 7A class has 27 kids, about half boys, who seem like typical well-dressed and decorous suburban kids, as the principal said, with few visible minority or ESL students. [OC:M seems to have them under tight control, and insisted on absolute quiet and no nonsense. There was little or no chatter, or socialization, or goofing about, silly remarks and so on, all very quiet, polite, and subdued.] Some of the kids examined me curiously, but most didn't pay much direct attention to me, and none talked to me, or asked what I was doing. The presentations went on until the bell went at 2:36, and the rest were to be finished the next day. I left quietly, after indicating to S. that I would be back for 2 periods at the end of the week to visit with her other 7 science class.

OC: I really felt the need to spend more time in S's classroom, in different subjects to try to get a better feel for her teaching style, interactions with students, management style, classroom atmosphere and so on. It was difficult to tell if the class was normally like this or whether they were on special orders, and best behavior. That is how much was my presence affecting what was going on? My hunch is that it had considerable effect. I get the impression from various telephone conversations that S wants to put things in their best aspect. For instance, around Halloween time they were a bit rambunctious, she said, so they were doing routine seatwork, so it wouldn't be worth my while coming in. Apparently, she had to be a "policewoman", marching them from one room to another in single file, or something of that sort.

This is something I must clarify with S in our first conversation—the effect I as observer might have on what goes on. I must stress that I don't want a "good show", as that defeats the purpose, but *as much as possible*, for it to be "business as usual" in that classroom, that I get a realistic picture of how the new "subject matter interacts with teacher and learners".

Somehow I didn't feel as comfortable in this classroom as I have in others recently, for instance those with a grouped table/ cooperative group setup. Perhaps I am less comfortable with formality and tight control than I used to be, when this was just what I wanted in my classes. Perhaps I also find lower SES/lower achiever /mischievous/lively classes more interesting than their middle class counterparts. However, S is a teacher and person that I have a great deal of respect and admiration for, a very nice person, and the kids seem nice enough. She seems to be very caring towards the kids, and is involved with kids during lunch, after school, and even on weekends with the "junior curlers". It will be very interesting to talk with her, and see her approach to technological problem-solving activities.

APPENDIX 4

Sample Conversational Interview Transcripts

1. Transcript

Susan Interview # 3

May 15, 1991, my basement office, 8:30-10:00 pm.

Q = researcher's question or comment

S = Susan's response or comment

Q: What does implementation of a curriculum mean to you?

S: It means carrying out the curriculum the way it specifies...to the best of your ability, and it also means meeting the needs of the students.

Q: Is it possible to do both?

S: It depends on the way the curriculum is written—if it gives some parameters to work within, then it's not that difficult, if you have resource material to do it with. With STS, because it's such a radical change from before, you need a lot of inservicing to change your thought processes, your teaching methodology. It takes a major change in the teacher too make it effective.

Q: Is "faithful implementation possible"?

S: For myself, to implement it the way it's delineated in the curriculum guide, with the resources we have: yes, because I like it, and because I have a strong science background in several areas. Subject specialists, like grade 8 earth science teachers, had trouble teaching the new material, and teaching issues. If they're educationally motivated, they'll do the best they can.

Q: You've talked about "modifying things" in your course. How does that fit in with implementation?

S: There's a lot of material in the resources [texts]—it's a matter of going through the two texts, and matching up with the flow they give, trying to do as many of the objectives as you possibly can. I'm still feeling my way through it, and that's a lot of work.

Q: If it comes down to what the curriculum spells out, and the kids' needs, which one do you give more precedence to?

S: The needs of the kids, because if you're not meeting their needs, you're not doing your job. The curriculum is there as a guide, and you do your best you can, but you've got to address the needs of the kids and look at where they're coming from. They don't have the background knowledge and experience, and you've got to go with them, otherwise it's an act of futility, and they'll turn off.

Q: The time factor—you've got six units, and six weeks to do each unit (M: That's insane!). Is the implementation of particular units in particular times possible, or desirable?

S: Six weeks to do a unit in junior high....is extremely difficult. With the amount of material, and the interest kids have in it, you just skim the top. That's my biggest bone of contention with the new program. The units themselves are incredibly interesting, it doesn't matter which one. All three areas are covered very well, though not equally divided. I feel you need two years, because of all the interruptions, all the things beyond the classroom that you've no control over. This time of year, in spring with track and field days, and field trips, and in winter with cold weather—like after Christmas when I had a week with almost no students—but that's not built in and you

don't have any kind of buffer. I'd sooner see four units over a year, with an optional one or two if you got through four.

Q: What if in a year you only finish two, three, or four units, and a government inspector comes along and says "you didn't implement the curriculum because you didn't do all of it"? Is it just a matter of how much you cover, or can you tell in other ways if you've implemented the curriculum?

S: One of the problems with this is evaluating: how do you evaluate? I'm not sure this is issue-related. There's holistic marking, there's major LA (language arts) in it that wasn't there before—it isn't all factual. If a government official was to come by and say that, I'd say, "fire me—I've done the best I can meeting the needs of the kids to the best of my ability". I know what the guidelines are for, but you have to blend the two.

Q: That's interesting. But what are curriculum committees for, in relation to what teachers are for? What should each be doing?

S: Supposedly curriculum committees have teachers who are actually teaching themselves that represent the voice of teachers in the province. Sometimes I think when we go to implement it...the amount of material alone.

Q: The amount of material is a problem...

S: Do you water it down to the point where you're doing it quickly, then what are you doing? You're not necessarily giving them something to work with, you're throwing it at them to get through it quickly. Is the intent exposure, or a little more depth, which they're very capable of in grade seven?

Q: You said at one point that next year you would water things down and cut back to make it fit.

S: Yes, exactly. In talking to someone at work, we both expressed concern. We can get through it, we can water it down, and people will ask how many units you've got through. I'm to the point where I won't say, because people give you looks as if to say "why not?". But I'd say I've done a good job with the ones I have done. I feel the kids are better able to address issues and are better informed. We are creating better citizens for the future. That's what I'd like to see, and there's motivation for science, for the science and technology society.

Watering it down? Yes I have to cut back, because there is the pressure, and the threat of a district exam. I don't know how they're going to do it. If the students don't perform you look at the teacher, not the kids.

Q: It sounds like that for you implementation is what the kids do.

S: That's where I'm coming from, since I feel the needs of the student are most important.

Q: They've enjoyed it, been interested...

S: And they've done well, really well. This last unit [microbes] we've done a combined social./language arts/math/science integrated unit—we built compost bins, that was the science component. We had a discussion before making them, and it was excellent. They're well informed and we had a good talk about it. They realize the importance of doing it, and every group wanted to take it [compost bin] home and use it and understand how to do it. That's a positive step—I've accomplished something. The way they've addressed the issues is by writing a letter to the editor [of a local paper]. They've taken so many science issues in that unit and they've applied it to their letter writing. So I felt that the time spent was worthwhile because they're better informed, and able to make decisions.

Q: Do we need curriculum committees? What if there were no curriculum committees and teachers were able to do their own thing on a district or school basis?

S: I think you need curriculum committees because you need a commonality. Otherwise people who are specialists will only do what they know best—you do what you are comfortable with. But that's not fair to kids, they need a smattering of different things. I feel the curriculum committees are sometimes not in touch with the reality of a classroom with thirty-five kids, and what resources and money are available. They expect you to do all these wonderful things, and many of the ideas are really good, but they develop and implement the curriculum before it's ready.. Well it [the new grade seven program] wasn't field tested for a year, and all the kinks ironed out. The last two [junior high science curricula] have been "here it is, do it, our timelines are short and we've got to get it out, and we've got the clout, so there will be no field testing". I don't think that's right.

I piloted two units, and we told them you can't do that [a unit] in six weeks, it's impossible, but there it is!

Q: You've mentioned that you liked it. Is that important? If a teacher didn't like it, would that affect implementation?

S: If they were not comfortable with something, I think they would tend to do it in the minimum length of time, and would tend to spend more time on what they know well. Over time, though, they become more comfortable, and the discomfort will dissipate.

Q: Change is a theme of this project. Has the program changed the way you teach, more than you've changed the program?

S: The program hasn't changed the way I teach because I've always taught with a lot of hands-on. The program has given me the opportunity to do what I've always believed in... Science is not one area. To be taught like it used to be: all of grade seven biological science, all grade eight earth science. I adamantly opposed that from the moment I hit junior high. Those kids aren't specialists, and they shouldn't be forced into a specialty.

So I've got no trouble with what's there, only trouble getting through it all in a meaningful way that the kids will appreciate. To give them time to do things—that's the biggest problem. They've got tremendous ideas, but they expect you to do it in one period, and it doesn't work, ...unless I'm giving them too much time...but I think they need it.

Q: So it hasn't produced any drastic change in the way you teach, or think about things?

S: No, I wouldn't say so. I try to do what they (curriculum guide) think is better, and I'll try it, I'll try it a couple of times before I won't do it again. I really try to assess it and talk to people. One of the problems that's come to light this year is I'm alone. In a bigger school, if two or three teachers are doing it (a course), they can get together and discuss and modify it, work the kinks out as things happen and come up with ideas. When you're on your own you have to rely on your own resourcefulness and sometimes what's obvious to others is not obvious to you.

Q: You have only one science colleague...

S: And he's not doing what I'm doing—he can give some suggestions, but he's not doing it himself. As to what others do, I'd like to think we're professional enough that if a change is deemed necessary, it's worth trying and if you're really unhappy with it you go to the consultant and express your concerns. But if people don't let others know, they only have themselves to blame, if something comes down the tube that says you're not doing your job right. (meaning not clear)

Q: Yours is a special situation, but even in bigger schools the teacher is isolated in the classroom.

S: If there's another person doing the curriculum, you can ask them how did it go, what do you think of this, did you try this, what do you think. The people who are at

even a worse disadvantage than me are people in a smaller school who are doing several subject areas. They've got a huge workload and even less time to think about what they're doing.

Q: Looking at the Microbes and Food unit (S: that worked out really well!), can you think of any specific instances when you thought the program was very successful?

S: The observation skills the kids developed were good, and [with] fine detail; working with the experimental vocabulary (control, manipulate, different variables). They were weak on that when we started, but by the time we'd done several experiments, they understood the concepts. I was surprised when they came into the class that they didn't have a better grasp of it. We did one experiment with potatoes, and by the time we did it and discussed it, it was obvious they knew.

Q: What was the experiment?

S: Take a potato and section it, pour salt on one, sugar on another, nothing on the third. Then we watched it for two or three days, left it for a while and watched the changes. They feel now that when they get into other experimental situations, or into grade eight, they'll be more aware...

Q: They have a feel now for what an experiment is.

S: Exactly, and what a control is, and what the manipulated variable is, and they use the terms effectively. The other positive thing is a greater awareness of the field of microbiology and the impact on their lives. They are consumers who have a great deal of responsibility now because they're babysitting, and their knowledge of food—they're responsible for other lives now.

Q: Did you do most of what was in the (microbes and food) chapter?

S: I skipped some things, and others we did as demonstrations.

Q: The bread mold experiment?

S: I did it and they watched, but not with a microscope.

Q: How did that work?

S: Good, really well. They were amazed at the change. I had two pieces of bread side-by-side in a container, one with preservative and one without, and it was really obvious.

Q: Did you use a lot of different [experimental] variables?

S: No, I didn't do that. They had such a good grasp of it from their observations, for example what happens in their locker with their lunches, that we didn't need to. I had a spin-off on this one (shows me the text) with the diseases. I took them to the library and they did a one day research on causes and treatment of diseases. The next day each child had a maximum of three minutes to get up and give the information to the class, and it was incredible what they had developed in that short time. Some had pictures, some had posters, and little bits of paraphernalia (?) they had dug up. They really enjoyed that, and I had them do a poem, "lines to a microorganism", which is a language arts spinoff. It was good—they really enjoyed it.

Q: These roles in the environment (referring to the text), did they get a grasp of that?

S: Oh yes. That took a bit more work. They had difficulty in separating producers and consumers, but the more we talked about it, the clearer it seemed to be. They enjoyed some of the stories about discoveries (Fleming and penicillin). I was able to relate it to something similar that happened in the classroom several years ago, and that gave it more meaning.***

Q: What about food poisoning and restaurants, "Keeping it Clean" (an activity in the text)?

S: Yes, we did that in groups and it went very well. They did some thinking on their own, then they got together and shared. We had one boy whose parents own a restaurant, who is a very slow learner. He was...just the centre...he knew all about

health regulations. He helped—had a tremendous amount of knowledge and was able to keep them straight on a lot of things.

Q: Did you get out to restaurants and do surveys or anything like that?

S: We didn't have any money for that, or time. I have to take them in class time, and there is no money for a bus. We did the balloon one (activity) with the yeast and that was tremendous. We had one set of results from a demonstration that didn't give a concrete answer, and I asked them why we had two different sets of results. They looked at it and said "they're not the same?". Why do you think we do experiments over and over again? Do you count one set of results as being absolute? It was wonderful—scientists don't do that, they're exploring or checking something hundreds of times.

Q: "Keeping Food Safe To Eat"?, "Food Preservation"? (sections of the text)

S: Yes, we went through all that. This one about scabby apples is tremendous, because it talks about fungicides and whether they should be used or not. There's no right or wrong, no concrete answer.

Q: How did you handle that, in groups?

S: No, I made up a worksheet, and we talked about the issue, and I had them look at both sides. What are the pros and cons? If you're an apple grower, what are the reasons? We wrote both down, and I said you have to make a decision, and you're decision is right based on the way you feel, but you have to be able to justify it. So I really emphasized that, and we went through the extension questions. As long as they can justify their answers, it's correct, acceptable. I find that now, they're much more willing to give me a reason. To me, that's important. At least, they are looking at the issue, and not saying, yes, this is right, or no, it is wrong. They realize they have to have reasons, and more background information.

Q: You felt they had enough background knowledge by this time to do a reasonable job?

S: For a couple of the extension questions, no, they needed to do more research. They understood it.

Q: Did you do any debates?

S: We were hoping to, but we lost time, with everything that happened around easter. Lost a week there, so there goes the debate.

Q: So you did cut off a bit.

S: I did, because I wanted to get on to another unit. I could have spent more time, but I think right now we've had enough (of this topic).

Q: Do you ever consult this? (the program of studies for grade seven science)

S: I look at it. I read it over before I start a unit to try to get a handle on it. And I look back at it from time to time because it's very easy to get off track, but it's [the program of studies] still fairly general.

Q: They suggest in the back of the text a societal decision-making model. Have you paid any attention to this?

S: I looked at it, and it's in the background, but the questions [in the text] lead them nicely into it, so that's it...it's built in, it flows. It's been quite easy to do and it lends itself to that. Glance at it—yes. Use it as a bible—no.

Q: From what you've said, they were considering alternatives and consequences and building a consensus?

S: And realizing that there are opinions on both sides, and both are valid, depending on the perspective they're coming from.

Q: You've said it's been successful and positive, but can you think of any instances in the unit or the program when it was not that successful, when you tried to implement it fairly faithfully, and it didn't work out?

S: A lot of the activities are very time-consuming. Were you to do them as they're delineated in the book, I found that... I gave the kids as many opportunities as possible to do "hands-on". They enjoyed it, but it took forever. By the end of the pilot year [the previous year], I hadn't got through as much as I could have. This year I did more demonstrations, but that's not the intent, which is for the students to do it themselves, but you have to have a bit of both.

Q: That's your tradeoff.

S: It has to be to get through it. There's no way you can meet all the curriculum objectives in every component [of the course], and let the students do everything themselves, because they don't function that quickly.

Q: Other than the time factor, were there any disasters, flops, anything the kids didn't enjoy?

S: If there was anything I left out, it wasn't because it was a flop, but because of the time. There were a couple of activities that looked so interesting, and I thought I don't have a week to give them the time to do a good job. For instance, a research activity. I've got some students who who are intense and really hard workers, and they get frustrated if they don't have sufficient time. If you rush them, it just backfires. There's where you're meeting the needs of the student. I said to them "we simply don't have time right now to do a good job". We'll talk about it, that's all.

Q: I think that's pretty amazing that there were no unsuccessful activities. In my long teaching career I can remember lots of instances where activities from prescribed textbooks didn't work.

S: If an experiment didn't work this year we didn't consider it a flop—we looked at it and discussed it, and said "what's wrong, what's different about this one".

Q: In the context of this course, that approach works, doesn't it? But perhaps in the previous type of science course, where there were always right answers, you were really up the creek then.

S: It was interesting that at the elementary science workshop I did, somebody asked me that: "What happens if we don't do it right, if we don't get the right answer"? I just looked at them and said "there is not necessarily a right and a wrong answer. You could have twenty right answers. That's what science is all about: it's not black and white, it's shades of grey, equally valid with justification.

Q: The question then becomes how do you get the grey more black, to eliminate some of the right answers?

S: A student doesn't have time to do this like a scientist with six weeks to get through a unit. That's where I have trouble. They need the time to develop those skills, but it's not really there. The ideas are there, but the time to do it is tight.

Q: We are getting into some good issues. One of the dilemmas that comes up is that of control. This has often stymied curriculum changes in science in the past. When you have different activities sometimes this implies a lessening of control of student, which is often a concern for teachers. Is it for you?

S: No. Control of junior highs is no different from control of elementary students. I have very firm discipline. Before we do any activity, I have very firm expectations of behaviour, and consequences for inappropriate behavior, and I stress safety. You always get one or two who test you and do something, but I don't have any difficulty that way. But then the kids say I'm really strict. I don't tolerate people who don't utilize every opportunity appropriately, and they don't like the way I react [to misbehavior], so they usually don't do it.

Q: I've noticed that your classes are very ...er..."on-task". They don't waste a lot of time chit-chatting.

S: Well there's no need, and they would waste the whole day if they had the opportunity. No, you have to keep them on task. They're so much happier when they know the rules and they know what they can do and what they can't, and they're happy because they come in and they're busy. I'm a proponent of the view that junior high students are simply little children inside big bodies.

Q: There's trend in some quarters to to associate STS science with a cooperative learning approach. You do a certain amount of group work and you like to balance this with individual work. You said before that you were concerned that in group work there is the possibility of losing control if the kids are in groups.

S: I forget what I said. I don't have any problem with group work. I think that it's important for kids to do both. Group work is good when it is controlled and when there are expectations laid out so it is productive. I mix groups all the time [S. uses name cards picked at random] and I never have the same groups, so children learn to get along and that's part of the learning environment. But I think individual work is also important because they have to develop individual work habits.

Q: I was thinking of the Johnson and Johnson type cooperative learning.

S: Well, they do a lot of that in social studies, and I have some difficulty with it, because in any group there are those who work and some who sit back and take the credit. I like to see both [individual and group work]. A long-term group: I don't know if in grade seven they are mature enough to handle it, I don't know if it's appropriate. There's so much bickering and infighting and changing of allegiances by friends. They're still little kids really, so a small group over a short period of time is effective but over a longer period of time, it's not for everyone.

It's like so many things in education—they jump on the bandwagon and it's a wonderful thing so everyone has to do it! But that doesn't work: you have to look at the needs of the individual. I would be adamantly opposed to it. Not every student works well in groups, so you're penalizing those those who work best individually. It can't be one thing or the other, it has to be a blend. You've so many different learning styles and personalities. It all comes back to meeting the needs of the student. Cooperative learning sounds like meeting the needs of the curriculum, not those of the student.

Q: So that's where curriculum starts, with the needs of the students?

S: You'd hope so!

Q: What about the needs of society?

S: Well, the needs of the student and the needs of society.....you have to adjust to both. The world of the junior high student revolves around themselves and today—not tomorrow, not yesterday. That's where it's got to start to be effective. The needs of society will come in time as they get older and more worldly. But you look at the age of the child and where they're functioning, in order to make something that will be effective and they'll buy into. So it's got to be the needs of the kids first. The societal stuff will come when they're a little older.

Q: What do you think are societal needs?

S: Being able to make relatively informed decisions, and we are approaching that. That came out in the secondary education review. The opinion from all over was that we need more people who are better informed. People that want to become scientists or whatever will do it no matter what.

Q: as long as you don't turn them off it...

S: And the old curriculum did. If they were really keen it didn't, but the ones who were marginal, who may well have gone with it when they were older and had a feel for their interests, got so turned off that they didn't want to do it at all...and we've got a generation of those right now.

Q: You've said that learning was being able to apply and use knowledge. There is some memorization, but mainly it's applying and using knowledge. Is that accurate?

S: I would say so. You need some background knowledge, but there's so much information out there you can't possibly hope to have it all.

Q: Coming back to teaching, if that's what it means to learn, what does it mean to teach?

S: Teaching has to consist of meeting that learning need. You give the basics they need, but also give the learner the tools...to make an informed decision.

Q: How do you do that?

S: Research skills, debate skills, discussion skills, giving them an awareness that there's no right or wrong. It's based on the needs of the individual, group or lobby. I wish I'd got that debate in. Next year I'm going to build that in, even if I have to leave out something else. That's a decision-making skill, a learning skill. Teaching is....looking at the learning style of the child, and giving them the tools to utilize it to the best of their ability.

Q: How do work habits fit into all this? You've got very specific ways you want them to lay out their notes for instance.

S: Work habits and study habits are critical for these kids. Teaching, then sequencing and giving them the tools on what they've gathered, so they can put it in some format, in order to review so that when they're studying they know where to go, what to do. They can use what they've gathered. Information gathering is a critical point. And I am very fussy about how they set things up, because the kids would put down three or four words and that would suffice. But if I ask them in a weeks time what they wrote, they don't have any idea. It's the level of the kids, and making sure they have the tools to do it.

I had a student in grade twelve come back and thank me...actually his younger sister. "You be glad she does it, [he said] because you can work through school". It's an organizational tool, because there's so much that's happening that you've got to learn what you've got.

Q: Did you pick that up from a particular teacher or school?

S: Yeah, yeah, (Q: That gal that influenced you so much?) ...because I believe that what she gave me in tools has helped, and you share that with others. It's really valuable. It doesn't work for everyone. For an abstract thinker, it may not work as well, and I'm not [an abstract thinker], and I show that. I modify it [work habits] if it's not working with a child. But for most of these kids, it really helps.

Q: That particular format that you use for setting up assignments, notes, and so on—you would carry that through whatever the curriculum was? Is it one of those perennial things?

S: It's just a tool to get the curriculum done in a way that's most beneficial. Kids still have to study, to write exams, and they've got to have something on paper.

Q: So we still have all the fixed points of our present educational system, exams, tests, grades, those will keep on?

S: They have to, to survive. Eventually they will get to university and it won't be any different. If they don't have the study skills, it's very difficult.

Q: Are they as important or more important than the actual content?

S: They go hand in hand, one feeds the other. Both are important.

Q: With science teachers generally, work habits are an important thing...

S: I've looked at the kids social studies and health notes, and they're similar. In language arts, it's good copy/rough copy, but dating of pages is similar.

Q: Part of the culture of schools...

S: Maybe...it could be.

Q: Your high school, university background, leading up to your entering teaching—could you do a summing up of that again, to get it on the record?

S: Starting back in high school, I had an interest in science. I loved it, and had a teacher in grade 12 [who influenced me], but not in grade 13. I found that when I got to university I'd learned enough from her [grade 12 teacher] that it got me through the first year, because I didn't learn anything in grade 13. He was not a good teacher, and we had more battles than anything else. He shouldn't have been a high school teacher, he was more research-oriented.

I worked with children in swimming, and as a camp counsellor from age sixteen. So I had a lot of experience, but never considered teaching as a career. I had wanted to be an oceanographer or a veterinarian. Part way through university I got married, and decided I couldn't handle being married and doing veterinary medicine. Oceanography at that time was a career, I was told, with no future in it for women. However, I could see that being married, I didn't want to be away from home that long [to complete another four years of veterinary medicine], so I completed a degree in honours biology—as close to veterinary medicine as possible. I realized in my last year, that my degree was too narrow, all mammals, so I took a plant physiology course, and had a minor in child psychology.

In fourth year I realized I didn't know what I wanted to do. The old adage: when in doubt, teach! I decided to try it and see if I'd like it. In my year at teachers college I tried everything, but I majored in high school biology. I had a terrible experience in high school as a student teacher, and I loathed the kids' attitude. I had a tremendously positive experience in junior high, and at several outdoor ed. camps, which was my minor, and I love it, it's biology and the application of environmental science. I tried teaching in the penitentiary system, and that was an eye-opener. I taught primary, a split 1/2/3 class, in an inner city school and didn't mind it. I would have never taught primary, if I hadn't had that experience, and then just did whatever happened then. I've never taught high school, but I've taught everything else. After fifteen years of teaching I have no regrets. I love it, but I think the experience of teaching children outside the classroom opens your eyes as to what to expect.

Q: That's about it, for now.

2. Transcript

Richard Interview # 2 (12 pp.)

November 8, 7:30-8:30 pm.

Q = researcher's question or comment

R = Richard's response or comment

Q: How would you say your students were doing in problem-solving [in the Structures and Design unit]?

R: This a math example from this last week. I gave them a question on volume...gave them the dimensions of a dog cage, and told them how much room a puppy would need, and asked them how many puppies would fit in the cage. And they thought nothing of punching the numbers into the calculator and coming up with "you could put 300,000 puppies in this cage", and that's how grade sevens think, ..a lot of them. That's how they get the answer. They don't bother stepping back, and it's really hard to push them back... and say "OK, look at what you've just said, is that at all reasonable?"

Q: That's one of the slogans you have up on your wall, isn't it?

R: Yeah, that's my big thing. I write it all over their quizzes and assignments, with a silly comment like "the big think".

Q: There was one point in the class the other day where you said "Do some planning before you start ripping". But did they?

R: Not very many did. I don't know if any group started and attacked with a plan before they started rolling and taping. So again, they just leap into it with both feet, without anticipating with a little bit of thought...

Q: I wonder if grade sevens can really plan like that? Do they have the necessary equipment, mental structures or ...

R: That's a good question, do they? ...When I was in grade seven I know I did...some things that took some careful planning from start to finish, and I've seen it in some of the kids...to say "Whoa, this is a stupid answer", and to think a little bit before they blurt out the answer.

Q: And the problem-solving skills in the structure and design unit, like "Understanding the problem", "Developing a plan"?...

R: Yeah that's the way it is in math, the four steps, understand the problem, develop a plan, carry out the plan, and then look back—and the kids are jumping from read the question to "do it" and stop, and it's so hard to get them into that cycle.

Q: Maybe most can't do it now...

R: I wouldn't say "can't", I would say they "aren't" doing it...I really don't think they can't, because when I stop them and say "is 300,000 puppies in this cage reasonable?", you get..." I guess it's a dumb answer", so that they are capable of seeing if things are reasonable or not, it's just whether or not they are using that skill.

Q: One of the things I wanted to talk with you about tonight is the students... What's a grade 7 student like? How are they different from other grades?

R: ...There are some generalizations that can be made. One is that the grade 7's are still a bit naive, a bit malleable, even gullible. You can still work with them, they still have a lot of their respect for the teacher. A lot of this has to do with the fact that they are the young ones in the school, they're still the little guys—they've moved to a new school. And in grade 8, they're the typical adolescents searching for their identity, going through puberty, trying out what they can try out,... attention-getting, silly things. The words, adolescent, juvenile, etc., seem to fit grade 8's much better than grade 7's or grade 9's. Grade 9's are the big ones in the school ...they're a little bit more

responsible and a lot more mature, the growth is most pronounced in grade 9, they start seeing themselves in the adult role,... there's definitely much more maturity in the grade 9's. The grade 8's... are the hardest group to handle, classroom control-wise. Grade 9's, I would place as the easiest, in that they work the hardest, they see the purpose in working. Grade 7's are also easy, in that they still have some measure of respect for what you're doing.

Q: What about in terms of their intellectual/academic characteristics?

R: There... I think it's absolutely impossible to talk in terms of any...generalization. I think of the class that you're observing.... I'll pick up on a few students: Joanne, for instance, is a really, really good thinker—she's lazy and hardly ever gets anything on paper, but she's a good thinker, and she's one of those that does stand back and look at her answers. I get the impression that she's been expected in the past to be reasonable, and to think, and has engaged adults in conversation, ...and she talks at a mature level.

In contrast, there's someone like Randy, where his answers are incredibly immature, and very much "just popped into my head so I'm saying it"—no thought, no reflection. And that's how he writes his exams— it's like word association when you mark his exams. And there are a lot of students in that category, but those are the two extremes, and the kids fall in between. I think that can be said for all three grades, but they start to pull towards Joanne's end, in grade 9. You do get much more thoughtful, mature answers on a grade 9 science test than on a grade seven test.

Q: That has implications for the curriculum materials.

R: Yeah, I think it would....

Q: What are you finding at the moment? Does the program and textbook hit about the right level for these kids?

R: Well it's twiggling their interest, ... and that's the first thing. If you want to get these kids to think, you have to find something they want to think about. Whether or not it's getting them to go to any great depth, I don't know...I have no basis of comparison...this program is in such contrast with the old program where we didn't expect them to think much: "you memorize these parts, and list these things in the right order". There weren't a lot of questions that were testing their thinking powers.

Q: You did have.... one success in critical thinking... with the digger wasp experiment.

R: There is that element of being able to analyse some statements.... they don't swallow anything whole, at least very few do. There are a few totally gullible ones that I could sell anything to,... but few.

Q: Does that depend on the context...how abstract it is?

R: If I took something completely out of their experience, I could convince them of anything...they have no basis to argue, they've never thought about it before. But that's the nice thing about this science course is, it's out of(from) their experience, so they do have something ..to relate to.

Q: It sounds like the best way to get these kids doing some thinking is through relevance and interest...

R: I think that's essential...

Q: ...rather than through implementing cycles...of process or problem-solving skills (first we recognize the problem, then we will hypothesize, then)

R: I think that's a bit unreasonable...I think even stating a problem is hypothesizing—implicit in stating a problem is that there is a hypothesis. When we're writing it up I have them separate them, but when we're doing an experiment, in the preamble discussion.. I like to throw everything out ..and then get it organized. I don't see everything so cut and dried,

..I don't see math or science problem solving as this funny little cycle ..in the curriculum guide. Start with a problem—yes, but then God knows where you go. And there's always a place too, in both subjects, for intuition. To start with a problem, lead to your solution, and then find a way of proving it.

Q: Funny though,... that word (intuition) never seems to creep into curriculum documents.

R: Yeah it doesn't..I don't care..intuition is a very important thng in my learning experience. The reason I did so well on exams is, I could read the question, have an inkling of what the answer is, and work towards it. I'm really big on doing estimates in math,on....instilling into these kids that same inkling..."OK, look at the question, have a feel for what the answer might be and work towards it", and that way you don't end up with 300,000 puppies in the cage.

Q: The other thing that's come up with students, is this notion of a changing student population. Have you noticed that? More behaviourially complex kids, as your vice-principal calls them?

R: No,... but what has changed is how we deal with these kids. There was a time when I could send a kid who swore to the office, and he would be kicked out of school, plain and simple. In contrast, this year a kid called me a XXX XXXXX! , he was back in my classroom 15 minutes later without so much as an apology. That we consider that anywhere near acceptable, ...if we are going to let the kids get away with that, of course we are going to see completely different behaviours. ...Yes, the behavior is different , but I really don't think the kids are. I think it's just the expectations are different. Plus we've lost the strap—I was never a great fan of it, ...but just having the threat there. ...There was a fight in my classroom yesterday, and those kids weren't kicked out of school..before, they probably would have been permanently expelled from school.

Q: Is it because there are just too many kids to kick out—the magnitude of the problem?

R: No,...kids realize very quickly how far they can can go, and they go that far. I think it's an administration thing...the current administration, when it was set up, stated that they were going to loosen things up, to appeal to kids' sense of reason, (I try to appeal to their sense of reason, and maybe it's not the best thing to appeal to [fear!]). The strap was out, expelling was out, except in extreme circumstances, etc.,and suddenly the teeth was taken out of anything we could do. ...As a result the behaviour changed, of course it would.

Q: This could affect your teaching methodologies.

R: Immensely...and it does. There's no way I teach the 7F's (the class you're observing) like my 7 A's. I can do just about anything with the 7A's, and they'll go along with it. I can try something, and if it falls flat on its face, and it won't bother those guys if it didn't work. But with the other class, if something falls flat on its' face, I'm dead meat, unless I have something else to back it up.

Q: You always have the one class,... *just* under control.

R: That's so much of what I have to do... with the 7 F group...is just control. And I resent having to be the one to exert that control—of course part of a teacher's job is classroom management—but I have resent having to have classroom management as my number one concern when I walk into that room. It's the only group I have like that..with my morning class it's just not a concern. Yes, it very much affects the way I approach the teaching. The thing that was running through my mind yesterday after the fight was...who has given me the authority to pretend to teach science to these kids, when they obviously need something much more basic..clearly, these two kids are getting nothing out of my science class.

Why am I even bothering? The curriculum is built on the assumption that kids want to learn, and I don't think that's a mistaken assumption in most cases. It's really obvious in that room: that a third of the kids just couldn't care less what I'm doing.

Q: I was watching them today, trying to get an idea of how engaged they were ...in the activity you were doing about the uses of objects. I don't think there were any who weren't engaged a large part of the time. Even the kids at the front desk, they were like this (R demonstrates: hand straight up, look of rapt attention). I wouldn't have thought that it would engage that group so much— (C: Nor would I)... "what can we use a glass rod for?" Once they got into it, they really started to think.

R: I was a little hesitant to ...I didn't think it would work, I had another thing ...to do if it didn't. It went really, really well, in my block 2..."so I'll give it shot and see what happens". And it went really well.

Q: Was there any difference in the number of ideas...?

R: Oh, there were far more ideas,...a wider range of ideas, in the afternoon, and firing at me, with no prying at all. Once they get into something, they certainly get into it. They go in waves, and if you can catch them in a wave, you're laughing.

Q: Another thing I wanted to talk with you about today was learning. It's something I've been puzzling about for long time—I used to think I knew what it meant at one time, but now I'm not so sure. What do you think?

R: Like you, learning once meant memorizing what they had to memorize, or developing the skills that had to be developed, so that when I gave the unit exam, they got a good mark. That was learning.

And certainly that doesn't cut it any more. I think learning is very closely related to ...gee, that's a tough question!...Learning means looking at the world in a slightly different way. For me,... when I learn something, I look at things differently. When I learned why the sky was blue, I looked at the sky differently,... since I learned how to find the area of a circle using calculus, I've always looked at circles differently, ...but I suppose I'm bizarre on that count.

Q: In the classroom, do you think of learning... in those terms?

R: I think...I do. Because I ask students to think, and is it reasonable? I'm attempt to judge whether or not they're learning by the quality of their answers—how they are able to look at things, and I'm trying to ask questions that require them to think, and if they're able to respond in a deeper way, that tells me that they're looking at those things differently, in a slightly more thoughtful way. Yeah, I think that I'm... using that definition of learning. It's a growth thing—you grow, you gain some knowledge, you gain experience, and you apply that. Yeah,...that's a good point. If you're able to apply this new knowledge, then you've learned it. If you've got a set of facts that you can regurgitate, that's not necessarily having learned anything.

Q: Looking at the first unit, Characteristics of Living Things, did you see any of this, like skills involving designing experiments and interpreting data..?

R: Certainly at the end of the unit, they were able to design a much better experiment—they were able to put in the control. At the start of the unit they saw absolutely no need to ..have two things to compare. I asked them to develop an experiment to see how much water you had to put on your lawn to get a nice green lawn. Consistently, in the first few days, everyone answered "just water it a lot to see how green it turns". At the end of the unit I asked them the same question, not having returned to it throughout the unit, everyone knew that you should do the back lawn and front lawn differently, or divide the lawn into several sections and water them differently to see the results. On that basis they were able to develop some sort of comparison, and hypothesizing, etc. was much stronger—developing experiments improved. I don't know ...if that means

they were thinking any better. They..gained some knowledge and they were applying it well...but were they thinking more clearly?...I don't know.

Q: It's an interesting question: how does just plain thinking relate to scientific thinking and mathematical thinking. Are they the same thing, ... just more refined versions of everyday thinking? Have you worked that out?

R: No I haven't..and I'm not sure if this is ...the answer I would give to that. Science and math I see as branches of philosophy. They're two branches of philosophy I'm really comfortable with, and if I have a difficulty, they're the two branches I fall back on. Nobody has demonstrated to me that these two approaches to knowledge are any more sound than some others that are available.. Last year this really came home to me with having having to read the philosophers and the different approaches to gaining knowledge, that science is just a philosophy. I think that's how I approach it in my class...this is one way of gaining knowledge...obviously all the answers we got using this approach are not correct, so it's not infallible. And it's nice to approach it that way—that science is not infallible—you can do this and still make mistakes, and I think.. the kids appreciate that too.

Q: A lot of students at the high school and college level seem to want the "right answers".

R: Yeah, they want the facts, but...sorry can't supply any.

Q: Do that have that "right answer anxiety" at the grade 7 level?

R: Less so, I think. My students often seem very comfortable with ambiguity and open-endedness, more comfortable than I was expecting,...because I'm a person that is really not comfortable with ambiguity in knowledge. I am becoming more comfortable, out of necessity.... there are a lot of things I can leave totally open and say haven't got a clue here. There was a time when I couldn't do that, and I don't know if it was my discomfort coming through or that of the students,... but they seem to be OK with the whole idea of "we don't know the answer", or "OK we can't find the answer to this".

Q: When ..you think about kids learning in math, and learning in science, is that something quite different?

R: ...I think in the kids perception, it still is. Math is something that always ends up with one number, it's always the right answer, and it's always written this way. This partly my problem ...I still have this fetish in math, this is how you set it up, and this is how I want to see you write it out. I'm trying to get away from it, and certainly the curriculum is aimed away from it...the whole idea that yes, there is room for divergent thinking in math. Not every problem has a single answer, not every problem can be answered. That's something I know—I have a strong background in math. It's just not something that comes across very often in grade seven, because every thing seems to be oriented to popping up the one number. So I think they still see math as very product-oriented, you always end up with the answer, and if you can't end up with the answer it's just because you don't know enough and somebody could answer it for you.

I am making an effort to get away from, and ...there are questions in the text with seventeen different answers, and you can defend every one of them.

Q: So learning in science, is gaining and applying knowledge, and viewing the world in a different way. When you are teaching...are you consciously thinking of learning occurring along those lines?

R: I think so. Once of the comments I make very often...I made it today in math..."this is something that's going to be useful to you guys, this is something you are going to use". Today it was converting volume to capacity measurements. I saw a few faces light up when they realized that the 750 cc engine is a 3/4 litre engine, and they never realized it before.

I don't think it's always there. Sometimes I'm just trying to get them to line up their decimals when they're adding numbers, ..but I think the big goal is " this is for you guys to carry out of this classroom and to use in your lives".

Q: So far you don't see any inconsistency between that and STS science?

R: No I don't,..if you focus on one specific activity, it's really hard to say where this carries outside of the classroom. Certainly, when you look at the broad aims, and where this fits in, yes, that's what the goal is. I don't know if I'm interpreting STS right, but that's my personal interpretation, one of the main themes.

Q: Your initial notions of the program...one of the things you had mentioned was that you thought it would be hard to run, and you were surprised at how well it did run, What kind of image did you have of the program before?

R: The image I had before was tainted by my image of my experience teaching science before, and that was very structured...the curriculum objectives are very much different from before... they are very...airy-fairy...loose, hard to nail down. That's what I was having problems with. How do I make a test to see if this has been accomplished, without realizing that this is something you watch for every day. So it was just getting a new mind set, ..I just can't approach this in the same way. As soon as I got that through my head, it didn't take long for things work well.

Q: How has this affected your evaluation, then?

R: Evaluation is something I'm having a really hard time with, because it's still very concept-oriented. I know how to mark that way, I know how to mark whether they know this or they don't know this. For developing experiments that was.. far more difficult to grade because ..I asked them to develop three or four and hand them in. I had to evaluate those on their merit. Have they got the essential features of an experiment, and what advice can I give, and then give them a mark out of ten. I could give them all the advice in the world on setting it up, but to translate it into a mark out of ten, and to translate that into a report card mark, it seems like a very dubious thing to be doing. The school requires a percentage grade...

Q: It's the jump from qualitative description to a quantitative measure....

R: Yeah, exactly, and it's not something I'm doing well—it's something I could use some help with.

Q: Have you looked at the teacher's resource manual?

R: Thank God we had the TRM when it came for doing the unit exam. We (three teachers get together for all the unit exams) put together a really strong unit exam, because it was very process/thinking oriented , something I would never have been able to do on my own, partly because I don't have the time to sit down and think up these really good questions.

Q: What other evaluation methods have you used, other than (written) tests? Any checklists or portfolios, or...?

R: They hand in all sorts of assignments...probably about half the activities in the textbook I've had them write up their results and hand them in, sometimes as group work, and sometimes individually. So I have ..my finger on what they're doing as we go along, and I think I have a feel , there. But it's exactly the same problem again, of..."this is his observations, and how he's interpreted this, but then suddenly I have to turn this into a grade. It's a tough thing to do, and also it's a tough thing to measure their progress as they go along.

One person in the room, Jason, he's another very spontaneous kid who says things off the top of his head that sometimes are very asinine, and sometimes they're very clever. But to compare the work at the start of the unit to the end of the last unit for Jason—and I mention him because he was the most startling contrast—it was incredible: the work that he was putting in, the thought that was going behind his answers, was there. But

I have a really hard time making that same comparison with most students. It's hard to keep track of sixty people from the start of a unit to the end of the unit.. Jason was obvious because there was such a marked change. Somehow I got Jason to slow down and think about what he was putting down on his page. It's really difficult to assess the others.

Q: The "Structure and Design" unit, what are your thoughts about it so far?

R: So far I really like the unit, because of the demand all the way through that the kids be thinking about something. Every thing is oriented to: "here are some basic facts, now go out and apply them". I like it..and when I'm able to ask a question and have the likes of Robby, or Kevin throw up their hand—they have thought of a response, I mean that's amazing, and I like it on that account.

Q: What about relevance? Is this the right thing for kids to be learning?

R: Relevance is an interesting thing. If you want to define relevance in terms of...what practical use will a grade seven kid have for knowledge of building bridges, then it's irrelevant. If you want to define relevance as..."are these kids interested in this topic?"—and that's how I prefer to define it—then, yeah, it's incredibly relevant.

Memorizing the parts of a cell is probably a pretty relevant exercise given that we are all composed of cells, but it's totally irrelevant to grade sevens, because they're just plain not interested. ...That's how I define relevance, and I'm sure every dictionary on earth would disagree with me. The content...factual content... is really irrelevant in this whole issue anyway, what's relevant is what they're learning in terms of applying knowledge, the content is just a vehicle, completely irrelevant to the discussion.

Q: So you're not too distressed...about this [Structure and Design] replacing some other area of traditional content in junior high?

R: No, no..they forget it anyway.